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Growth Controls and Land Values in an Open City

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ABSTRACT

This paper analyses the impact of a growth control law on land values using a variant of the open-city model of Capozza and Helsley (1988). Since population growth in the model generates a negative externality, a growth control regulation raises urban land rents by improving the city's quality of life. The control also delays development, however, and both these effects must be taken into account in determining land value changes.

Growth Controls and Land Values in an Open City

by

Jan K. Brueckner*

1. Introduction

In the face of rapid regional population growth, many localities in the U.S. have turned to growth controls in an attempt to divert unwanted extra residents to other communities. These controls take a variety of different forms, including reductions in allowable development densities, increases in development fees paid by builders, annual building permit limitations, timing ordinances designed to delay development, and various other regulations. Rosen and Katz (1981) provide a excellent survey of regulations adopted by communities in the San Francisco Bay Area, where growth controls are commonplace.

There is now a large empirical literature documenting the effects of growth controls on housing and land markets. The evidence to date conclusively establishes that growth controls raise housing prices in communities where they are imposed (see Elliot (1981), Schwartz, Hansen, and Green (1981), Dowall and Landis (1982), Schwartz, Zorn, and Hansen (1986), and Katz and Rosen (1987)). Additional evidence suggests that by delaying or banning eventual development, imposition of growth controls lowers the value of agricultural land near the city (see Gleeson (1979), Black and Hoben (1985), Knapp (1985), Vaillancourt and Monty (1985), and Nelson (1988)).[1]

The literature identifies two forces that account for the positive impact of growth controls on housing prices. First, by restricting the supply of housing in the face of population pressure, controls are thought to create excess demand, which in turn leads to higher prices. Second, by preserving a community's "quality of life," controls create an amenity whose value is then capitalized into housing prices.[2] Unfortunately, despite much cogent discussion of these forces, the literature does not offer a formal dynamic model that illustrates their operation. The purpose of the present paper is to offer a first step toward such a model.

Building on the framework of Capozza and Helsley (1988), the model focuses on the land development decision (conversion from rural to urban use) of a landowner operating with perfect foresight in an dynamic open-city environment. The time path of urban land rents in the model in part reflects the presence of a negative population externality (a large population lowers the city's quality of life and reduces the rent that urban land commands). After deriving the optimal date of rural-urban conversion (the date that maximizes land value), the analysis considers the effect of a growth control regulation, which delays conversion at each location. The model's population externality is, of course, the key factor in the analysis. Given the externality, a slowing of population growth due to the control raises land's rent in urban use at every date and location as consumers pay a premium to live in a smaller city. For land that is already developed, imposition of the control raises all future rents and therefore increases the value of the land. This corresponds to the amenity effect of growth controls that has been identified in the literature.

The control's impact on the value of undeveloped land is, however, not as straightforward as the literature would suggest. The impact is the net effect of two changes: first, the control delays the date at which urban rents can be earned, which lowers value; second, the control yields a lower population path (and hence higher urban rents) after development, which raises value. Since the second of these effects may dominate, growth controls can raise the value of undeveloped land in some locations, in contrast to the literature's implicit assumption to the contrary. The analysis attempts to pinpoint the locations of undeveloped land that benefit from the imposition of a control. In addition, the paper derives the form of the optimal growth control policy, which maximizes the total value of land in the city. This policy can be used as a benchmark in evaluating other growth control programs. As a final exercise, the paper explores an example based on a specific utility function, where various urban growth paths can be computed explicitly.

It is important to realize that, because an open-city model is used in the analysis, excess demand for housing (as discussed above) plays no role in determining the market impact of growth controls. Consumers denied residence by the presence of the control simply relocate to other communities. Since it eliminates population pressure as a market force (focusing instead on the control's amenity effect), the analysis may not offer an entirely accurate picture of the operation of actual growth controls. However, it is useful to gain an understanding of the working of an amenity-based model. Once the analysis of the model is complete, the paper sketches a closed-city model of growth controls (where population pressure is a factor), and points out some problems that arise under such an approach (political issues are also discussed).[3]

2. The Model and the Uncontrolled Equilibrium

In standard fashion, the city is assumed to be radially symmetric, with all employment located at the CBD. Radial distance to the CBD is represented by x, and commuting cost from a residence at distance x equals kx, where k is a positive parameter that is constant over time. Urban residents, all of whom are identical, earn income $y(t)$ at time t. Preferences are given by the well-behaved utility function $U(g,\ell,P)$, where ℓ is consumption of land, g is consumption of a numeraire nonland good, and P is urban population. The marginal utility of population U_P is nonpositive, with population becoming a disamenity ($U_P < 0$) when P is sufficiently large. This externality presumably arises from traffic congestion, air pollution, crime, and other phenomena associated with a large population. For simplicity, these underlying forces are not modelled in detail.

To further simplify the analysis, individual land consumption is fixed at one unit per person (this assumption is inessential, serving only to simplify notation). The budget constraint then becomes $g + r + kx = y(t)$, where r is land rent per acre. Land rent is determined via the open-city assumption, under which the time path of utility is given by an exogenous function u(t). Substituting for c using the budget constraint, urban residents achieve utility u(t) when r satisfies the equation

$$U[y(t)-r-kx,\ 1,\ P] = u(t). \qquad (1)$$

This equation implicitly defines the urban land rent function $r = r(t,x,P)$, with $r_x = -k < 0$, $r_P = U_P/U_g \le 0$, and $r_t = y'(t) - u'(t)/U_g$. Land rent is a decreasing function of distance from the CBD, and for given t and x, a higher population reduces rent via the disamenity effect (for low P's, this effect is absent). It is assumed that $r_t > 0$, so that holding x and P fixed, rent is increasing over time. This requires that income is increasing sufficiently rapidly (or falling sufficiently slowly) relative to utility.

Land is owned by absentee landlords who decide on the time pattern of its use (agricultural vs. urban) to maximize the present value of rents. Land earns a rent of r_a per acre when in agricultural use, and conversion to urban use entails a cost of D per acre.[4] Consider the optimization problem at time zero of a landlord with holdings at location x. Letting P(t) denote the (equilibrium) population growth path of the city and assuming that the landlord has perfect foresight, his goal is to choose the conversion date T to maximize

$$\int_0^T r_a e^{-it} dt + \int_T^{\infty} r(t,x,P(t)) e^{-it} dt - De^{-iT}, \tag{2}$$

where i is the constant discount rate. For future reference, expression (2) (which is land value per acre) will be denoted $V(T,x,0|P)$. V gives the value at time zero of land at location x as a function of the conversion date T, conditional on the population growth path P. The first-order condition for choice of T is

$$r(T,x,P(T)) = r_a + iD, \tag{3}$$

which shows that the land should be converted when urban rent equals agricultural rent plus the flow cost of conversion. The second-order condition requires that the total derivative of r with respect to time ($dr/dt = r_t + r_P P'$) is positive at the optimal T. Given that $r_x < 0$, it then follows that T is an increasing function of x, indicating that the city grows outward over time ($dT/dx = -r_x/(dr/dt) > 0$). Aside from the population externality, this model is identical to that of Capozza and Helsley (1988).

The population growth path P(t) is in fact determined by the conversion decisions of landlords, and this must be recognized in solving for the equilibrium of the model. The first step in doing so is to note that (3) can reinterpreted as giving the x value where development is occuring at a given time. That is, rewriting (3) as $r(t,x,P(t)) = r_a + iD$, the equation determines the location x of land being converted at time t. But since the city grows outward, this x value (call it $\bar{x}$) is in fact the boundary of the city at time t. Then, recalling that individual land consumption is fixed at one unit, population P can be written $\pi\bar{x}^2$. Substituting this expression in place of P(t) in the above equation yields

$$r(t,\bar{x},\pi\bar{x}^2) = r_a + iD. \tag{4}$$

This equation determines the time path $\bar{x}(t)$ of the urban boundary along with the equilibrium population growth path $P(t) = \pi\bar{x}(t)^2$. The inverse of the function $\bar{x}(t)$, written T(x), gives the conversion date T at location x.

Totally differentiating (4), it is easily seen that $\bar{x}'(t) = -r_t/(r_x + 2\pi\bar{x}r_P)$. A necessary and sufficient condition for the assumed outward growth of the city is therefore $r_t > 0$ (recall r_x, $r_P < 0$). This condition also guarantees satisfaction of the developer's second-order condition.[5] Substituting T(x) and the equilibrium population path into (2), the value of land in equilibrium is written $V^*(x,0) \equiv V(T(x),x,0|\pi\bar{x}^2)$.

Before proceeding to the discussion of growth controls, one final assumption is useful. The assumption is that $\bar{x}(0) = 0$, which means that the city starts out as a point at time zero. This, of course, is simply a matter of specifying the time origin.

3. Growth Controls and Land Values

In the early stages of urban growth, population size is a matter of indifference to consumers, with U_P and r_P both equal to zero. At some point, however, the population externality comes into play, so that U_P and r_P become negative. Suppose that along the city's equilibrium growth path, r_P is zero for all x when $t \le s$ and negative for all x when $t > s$ (in other words, $r_P(t,x,\pi\bar{x}(t)^2) = (<)\ 0$ as $t \le (>)\ s$). Although it can be shown that r_P must have the same sign for all x, r_P is not guaranteed to remain negative after it first falls below zero (it could conceivably become zero again at some future date).[6] To avoid inessential complications, however, this is assumed to not happen.

Suppose that in response to the population disamenity, the city imposes a growth control law at time s. This law takes the form of a restriction on the future growth of the urban boundary. Formally, the law specifies a new time path $\bar{x}_c(t)$ for the boundary beyond s, with $\bar{x}_c(t) < \bar{x}(t)$ holding for $t > s$ (see Figure 1 for an example). Since the law delays development, the conversion date function T(x) is also replaced by a new function $T_c(x)$, which satisfies $T_c(x) > T(x)$ for x values beyond $\bar{x}(s)$ ($T_c(x)$ is the inverse of $\bar{x}_c(t)$). Of course, the law could be written as a "growth management timing ordinance" (Rosen and Katz (1981)), in which case the law would directly specify $T_c(x)$. An important assumption is that imposition of the growth control is unanticipated by developers. Without this assumption, development activity might accelerate in anticipation of the control.

With $\bar{x}(t)$ replaced by $\bar{x}_c(t)$, the population growth path of the city beyond s is lowered from $P(t) = \pi\bar{x}(t)^2$ to $P_c(t) = \pi\bar{x}_c(t)^2$. Consumers denied residence in the city locate elsewhere in the economy. It is important to note that this redirection of population has no effect on the time path of utility in the economy (recall that the function u(t) is exogenous). For such an effect to be absent, the city imposing the control must be small relative to the rest of the economy. The consequences of relaxing this implicit assumption are discussed below.

Since the lower population growth path improves the city's quality of life relative to the equilibrium path, current and future urban land rents rise. Conversion of undeveloped land is also postponed by the control, and together, these two effects lead to windfall changes in land values throughout the city. Consider first the change in the value of developed land. Since the conversion cost D has already been incurred for such land, value is simply the present value of the flow of future (urban) rents. Therefore, prior to the imposition of the growth control at date s, the value of a developed acre at location x is given by

$$V^{*d}(x,s) = \int_s^\infty r(t,x,\pi\bar{x}(t)^2)e^{-i(t-s)}dt. \tag{5}$$

(the superscript denotes developed land). After imposition of the control, the value of the same acre of land is

$$V_c^{*d}(x,s) = \int_s^\infty r(t,x,\pi\bar{x}_c(t)^2)e^{-i(t-s)}dt. \tag{6}$$

The rent expressions in (5) and (6) differ because the growth control changes the city's population path. With population growth slowed under the control, rent is higher and land value greater. In other words, with $\bar{x}_c(t) < \bar{x}(t)$ for $t > s$ and $r_p(t,x,\pi\bar{x}(t)^2) < 0$ holding by assumption beyond s, it follows that (6) exceeds (5) and that the control raises the value of developed land.[7]

Consider now the growth control's effect on the value of land that remains undeveloped at time s. Prior to imposition of the control, the value of an undeveloped acre at location x is

$$V^*(x,s) = \int_s^{T(x)} r_a e^{-i(t-s)}dt + \int_{T(x)}^\infty r(t,x,\pi\bar{x}(t)^2)e^{-i(t-s)}dt - De^{-i(T(x)-s)}. \tag{7}$$

After imposition of the control, value equals

$$V_c^*(x,s) = \int_s^{T_c(x)} r_a e^{-i(t-s)}dt + \int_{T_c(x)}^{\infty} r(t,x,\pi\bar{x}_c(t)^2)e^{-i(t-s)}dt - De^{-i(T_c(x)-s)}. \qquad (8)$$

To compare these expressions, it is useful to rewrite (8) as

$$V_c^*(x,s) = \int_s^{T_c(x)} r_a e^{-i(t-s)}dt + \int_{T_c(x)}^{\infty} r(t,x,\pi\bar{x}(t)^2)e^{-i(t-s)}dt - De^{-i(T_c(x)-s)} + \int_{T_c(x)}^{\infty} [r(t,x,\pi\bar{x}_c(t)^2) - r(t,x,\pi\bar{x}(t)^2)]e^{-i(t-s)}dt \qquad (9)$$

Recalling that $V^*(x,s)$ is equal to $V(T(x),x,s|\pi\bar{x}^2)$ (see (2)), it follows that the difference between pre- and post-control land values can be written

$$V^*(x,s) - V_c^*(x,s) = V(T(x),x,s|\pi\bar{x}^2) - V(T_c(x),x,s|\pi\bar{x}^2) - \int_{T_c(x)}^{\infty} [r(t,x,\pi\bar{x}_c(t)^2) - r(t,x,\pi\bar{x}(t)^2)]e^{-i(t-s)}dt. \qquad (10)$$

Note that $V(T_c(x),x,s|\pi\bar{x}^2)$ is equal to the first three terms in (9). By repeating the argument used above, it follows that the integral in (10) is positive (r_p is negative along the the equilibrium path, and $\bar{x}_c(t) < \bar{x}(t)$). To sign the difference between the first two terms, note that by definition, $T(x)$ maximizes $V(T,x,0|\pi\bar{x}^2)$ ($T(x)$ is the optimal conversion date under the equilibrium population path). As a result, $T(x)$ also maximizes $V(T,x,s|\pi\bar{x}^2)$.[8] Since conversion date $T_c(x)$ is, by contrast, nonoptimal under population path $\pi\bar{x}(t)^2$, it follows that $V(T(x),x,s|\pi\bar{x}^2) >$

$V(T_c(x),x,s|\pi\bar{x}^2)$. The difference between the first two terms in (10) is therefore positive. With the integral also positive, the sign of the entire expression is indeterminate, indicating that the value of undeveloped land can rise or fall when the control is imposed.

As explained in the introduction, the reason for this indeterminacy is that the growth control has two opposing effects. The control delays the date at which urban land rents can be earned, which tends to reduce value, but it lowers the population growth path (and thus raises rents) after development, which tends to increase value. Despite this general indeterminacy, the change in land value can be signed under some circumstances. Consider first the case of a "marginal" control, which involves only a slight delay in development at each location. Under such a control (illustrated by the dotted line in Figure 1), $T_c(x)$ for $x > \bar{x}(s)$ can be written $T(x) + \delta(x)$, where $\delta(x) > 0$ is infinitesimal. Similarly, $\bar{x}_c(t) = \bar{x}(t) + \varepsilon(t)$ for $t > s$, where $\varepsilon(t) < 0$ is again infinitesimal. The change in the population path induced by the control can then be written $\pi\bar{x}_c(t) - \pi\bar{x}(t)^2 = 2\pi\bar{x}(t)\varepsilon(t)$. Under these assumptions, the land value difference in (10) becomes

$$V^*(x,s) - V_c^*(x,s) = V_T(T(x),x,s|\pi\bar{x}^2)\delta(x) - \int_{T_c(x)}^{\infty} r_p(t,x,\pi\bar{x}(t)^2)2\pi\bar{x}(t)\varepsilon(t)e^{-i(t-s)}dt. \tag{11}$$

Since $T(x)$ is the optimal development date, it follows that the partial derivative V_T equals zero when evaluated at $T(x)$. Eq. (11) then reduces to the negative of the integral in the second line, an expression which is positive given that $r_p < 0$ along the equilibrium path and $\varepsilon(t) < 0$. Imposition of a marginal control therefore <u>increases</u> the value of all undeveloped land (the increase, of course, will be small). The reason is that since the control is marginal and initial conversion dates are optimal, the loss of value from delayed development vanishes. The gain in value from a lower population growth path remains, however, so that the net effect is positive.

Now consider the case of where the control is not necessarily marginal but is "continuous" in the sense that the limit of $T_c(x)$ as x approaches $\bar{x}(s)$ from above equals $T(\bar{x}(s))$). This means that the control does not interrupt the development process when it is first imposed. Equivalently, continuity of the control means that the function $\bar{x}_c(t)$ is increasing near s, as in Figure 1. If $\bar{x}_c(t)$ were flat near s, then the urban boundary would initially be frozen by the control, and $T_c(\bar{x}(s))$ would exceed $T(\bar{x}(s))$ (the control would then be discontinuous).[9]

Under a continuous control, the land value difference in (10) can be signed at locations near the urban boundary. To see this, consider the behavior of (10) as x falls toward $\bar{x}(s)$. Since $T_c(x) \rightarrow T(x)$ as $x \rightarrow \bar{x}(s)$ by continuity of the control, it follows that the difference between the first two terms of (10) approaches zero as $x \rightarrow \bar{x}(s)$. With the last term in (10) negative for all x, the entire expression therefore becomes negative as x approaches $\bar{x}(s)$. It follows that the imposition of the control raises the value of undeveloped land adjacent to the urban boundary. To relate this result to the previous discussion, note that a continuous control is necessarily marginal near the urban boundary. By the previous analysis, land value must rise in such locations.

If the growth control is discontinuous, with $T_c(\bar{x}(s)) > T(\bar{x}(s))$, then the first part of (10) remains positive as x falls toward $\bar{x}(s)$, and the land value difference cannot be signed. The difference is determinate, however, in one highly discontinuous case: where the control prohibits development beyond

$\bar{x}(s)$. With future development banned, $T_c(x)$ is infinite for $x > \bar{x}(s)$, and the integral in (10) equals zero. Since the rest of the expression is positive, it follows that land value falls when the control is imposed (value at each location falls by the present value of the difference between agricultural and forgone urban rents).

Returning to the case of a continuous control, it is natural to wonder whether more complete results on the control's spatial impact beyond $\bar{x}(s)$ can be derived. To address this question, an appropriate procedure is to compute the derivative of the land value difference (10) with respect to x. If this derivative were positive, then (given that land value rises near $\bar{x}(s)$) it would follow that value rises in response to the control between $\bar{x}(s)$ and some $\hat{x}$ and falls beyond $\hat{x}$ ($\hat{x}$ could be infinite). Unfortunately, the derivative in question is ambiguous in sign, so that this simple spatial pattern of value impacts need not emerge. To see this, subtract (8) from (7) and differentiate with respect to x. The result is

$$- \int_{T(x)}^{T_c(x)} ke^{-i(t-s)}dt \;+\; T_c'(x)e^{-i(T_c(x)-s)}[r(T_c(x),x,\pi x^2) - r_a - iD]. \tag{12}$$

(recall that $r_x = -k$). To sign the second term in (12), note first that $T_c'(x) > 0$.[10] Moreover, since $r(T(x),x,\pi x^2) = r_a + iD$, $r_t > 0$, and $T_c(x) > T(x)$, it follows that the term in brackets is positive. With the entire second term therefore positive and the integral negative, the sign of (12) is indeterminate. As a result, the impact of the growth control on the value of undeveloped land may have a complex spatial pattern. For example, after rising near $\bar{x}(s)$ when the control is imposed, value may fall farther from the boundary only to rise again at still more distant locations.

The previous results stand in sharp contrast to the usual claim that growth controls reduce the value of undeveloped land. It has been shown that if a city imposes a very mild growth control (a marginal control), then the value of all undeveloped land rises. If the control is instead a stringent one that happens to be continuous, then the value of undeveloped land near the urban boundary rises, and more remote land may rise in value as well. As mentioned in the introduction, empirical evidence suggests that growth controls reduce the value of undeveloped land, a finding that is not fully consistent with the above results. There are a number of possible explanations for this inconsistency. First, land value gains near the urban boundary may be hard to pick up empirically, especially if the estimating equation does not allow for interaction between location and the effect of the control. Second, actual controls may be quite discontinous, in which case all undeveloped land may fall in value. Whatever the explanation, future empirical investigators should be aware that the impact of a control on the value of undeveloped land need not follow conventional wisdom.

4. The Efficient Growth Control

The preceding analysis focused on the effects of an arbitrary growth control law. The purpose of this section is to derive the form of the efficient growth control. Since consumer utility is exogenous in the model, the planner's goal in choosing an efficient control is simply to maximize the total value of land in the city (this maximizes returns accruing to landlords).

To derive total land value, the value expression (2) is integrated across all locations x in the planner's jurisdiction. This yields a double integral involving land rents that is not convenient to use. A more useful expression is gotten by reversing the order of integration, with integration occuring first over distance and then over time. The present value of total land rent can then be written

$$\int_{t=0}^{\infty} \left\{ \int_{x=0}^{\bar{x}_e(t)} 2\pi x r(t,x,\pi\bar{x}_e(t)^2)dx + \int_{\bar{x}_e(t)}^{B} 2\pi x r_a dx \right\} e^{-it}dt. \tag{13}$$

The first inside integral is total urban land rent at time t (the city boundary at t under the efficient control is denoted $\bar{x}_e(t)$, with total population equal to $\pi\bar{x}_e(t)^2$). The second inside integral is total agricultural rent at t. Note that the upper x-limit B represents the outer boundary of the planner's jurisdiction (the jurisdiction could be visualized as a circular island with radius B). Total land rent (the sum of these two integrals) is then discounted and integrated from time zero onward.

Total conversion cost in present value terms is found by multiplying the last term of (2) by $2\pi x$ and integrating over x, which yields

$$\int_{x=0}^{B} 2\pi x De^{-iT_e(x)}dx, \tag{14}$$

where $T_e(x)$ is the efficient conversion date for land at x. To make (14) commensurate with (13), a change of variable from x to t is performed and the resulting expression is integrated by parts. This yields the following equivalent expression for total conversion costs:[11]

$$\int_{t=0}^{\infty} \pi\bar{x}_e(t)^2 iDe^{-it}dt. \tag{15}$$

The efficient growth control is found by choosing $\bar{x}_e(t)$ to maximize the difference between (13) and (15), which equals total land value. Note that since the planner's jurisdiction stops at x = B, the optimal boundary path must satisfy $\bar{x}_e(t) \leq B$. Differentiating the total value expression inside the time integral, the first-order condition for choice of $\bar{x}_e(t)$ is

$$r(t,\bar{x}_e(t),\pi\bar{x}_e(t)^2) = r_a + iD - \int_0^{\bar{x}_e(t)} 2\pi x r_P(t,x,\bar{x}_e(t)^2)dx \qquad (16)$$

This condition differs from the previous first-order condition (3) by the presence of the integral, which is nonpositive given $r_P \leq 0$. The interpretation of the difference is straightforward. The negative of the integral represents an additional cost of converting land from agricultural to urban use, over and above the foregone agricultural rent and the opportunity cost of the funds spent on conversion. This cost is the reduction in the rent on previously converted land that comes from the population growth caused by further conversion.

When this cost is taken into account, the spatial growth of the city is slowed relative to the equilibrium path. No effect occurs, however, before time s ($\bar{x}(t) = \bar{x}_e(t)$ for $t \leq s$). This can be seen by noting that since r_P equals zero along the equilibrium path before s, the first-order condition (16) is satisfied by $\bar{x}(t)$ in this range. Beyond s, the fact that $r_P < 0$ holds along the equilibrium path means that the RHS of (16) exceeds the LHS along this path. From the second-order condition,[12] it follows that the boundary must be contracted relative to the equilibrium path to satisfy (16). As a result, $\bar{x}_e(t) < \bar{x}(t)$ holds for $t > s$.[13]

Under suitable smoothness assumptions on the land rent function r, $\bar{x}_e(t)$ will diverge from $\bar{x}(t)$ in a smooth manner at $t = s$. This means that $\bar{x}_e(t)$ must be increasing in t immediately after s, which in turn implies that the efficient control is continuous.[14] The previous section's results on the land value impacts of a continuous control then apply. In particular, land near the urban boundary rises in value when the efficient control is imposed. Other undeveloped land may fall in value, but given the efficiency of the control, total land value rises. Of course, imposition of an arbitrary control, continuous or otherwise, may not have this effect (the control could reduce total land value).

5. An Example

To generate a simple example, suppose that the utility function U(g,1,P) is given by $g - \alpha P^{1/2}$, where $\alpha > 0$ (land consumption ℓ is suppressed since $\ell = 1$). Suppose also that income and utility vary linearly with t, with $y(t) = \gamma + \phi t$ and $u(t) = \tau + \rho t$. Then, using (1), $r = \eta + \theta t - kx - \alpha P^{1/2}$, where $\eta = \gamma - \tau > 0$ and $\theta = \phi - \rho > 0$. Eq. (4) then becomes

$$\eta + \theta t - k\bar{x} - \alpha(\pi\bar{x}^2)^{1/2} = r_a + iD, \tag{17}$$

and solving for $\bar{x}$ yields

$$\bar{x}(t) = (\sigma + \theta t)/\beta, \tag{18}$$

where $\sigma = \eta - r_a - iD$ and $\beta = k + \alpha\pi^{1/2}$. For $\bar{x}(0) = 0$ to hold as assumed, σ must equal zero, which then makes $\bar{x}(t)$ equal to $(\theta/\beta)t$.

Since the population externality is present under the given utility function for all values of P, the critical date s in the preceding analysis is equal to zero (growth controls are imposed immediately). Consider the optimal growth control first. To find its form, note that since $r_P = -(\alpha/2)P^{-1/2}$, the integral in (16) is $(\alpha/2)(\pi\bar{x}_e(t)^2)^{-1/2}\int_0^{\bar{x}_e(t)} 2\pi x dx = (\alpha/2)\bar{x}_e(t)\pi^{1/2}$. Adding this expression to the RHS of (17) and solving for $\bar{x}_e$ yields

$$\bar{x}_e(t) = (\theta/\beta_e)t \tag{19}$$

where $\beta_e = k + (3\alpha/2)\pi^{1/2}$ ($\sigma = 0$ is used). Since $\beta_e > \beta = k + \alpha\pi^{1/2}$, it follows that $\bar{x}_e(t) < \bar{x}(t)$ for $t > 0$.[15]

With the distance to the urban boundary proportional to t under both the equilibrium and efficient growth paths, it is interesting to consider the entire class of linear paths, where the boundary distance at t is equal to λt for some $\lambda > 0$. Since it can be shown that total property value is a single-peaked function of λ, a picture such as Figure 2 applies. Total property value increases as λ falls from θ/β, reaching a maximum at $\lambda = \theta/\beta_e$. Further reductions in λ reduce total value, with value falling to an expression equal to the present value of agricultural rent as λ approaches zero ($\lambda = 0$ corresponds to a total development ban). Figure 2 shows that while a moderate control can raise total property value above the equilibrium level, a stringent control leads to a reduction in total value.[16]

6. Political Considerations and Closed-City Analysis

Up until now, no mention has been made of the political forces leading to the imposition of growth controls. Note first that since utility is fixed in the analysis, consumers are indifferent to the presence of a control (quality-of-life gains are dissipated in higher land rents). Landlords, however, have a strong interest in the nature of the control law. Imposition of a particular growth control will be supported by landlords who stand to reap windfall gains under the law and opposed by landlords who expect windfall losses. For a particular control to be politically viable, the gainers must have more political clout than the losers.

Since gainers and losers under many growth-control proposals will correspond roughly to the owners of developed and undeveloped land, a political struggle between these groups is likely. Interestingly, in one case where this matchup is exact (the case of a complete development ban after date s), owners of developed land reap the largest possible gains. If this group is sufficiently powerful relative to owners of undeveloped land, a development ban might well be imposed. By contrast, in a Coasian world where transactions costs are absent, any growth control (development ban or otherwise) that lowers total land value is not politically viable. The reason is that potential losers are better off paying gainers to vote against it. In such a world, adoption of an efficient growth control is in fact a likely outcome.[17]

With this brief discussion of politics in mind, a natural next step is to investigate a growth-control model where consumers are not indifferent to the presence of the control. The obvious way to construct such a model is to assume that the city is closed rather than open, with a population growth path that is fixed exogenously.[18] Once the closed-city assumption is imposed, however, the growth control can no longer have an effect on the city's quality of life (the control restricts spatial growth, but this simply packs the population into a smaller area without affecting its size).[19] As a consequence, land value changes induced by the control have no amenity component. Increases in the value of developed land are purely the result of a supply restriction in the face of a growing population. Similarly, the control's only impact on undeveloped land is to delay conversion, which unambiguously reduces its value in the absence of an amenity effect.

Identification of gainers and losers among landlords is easy in the closed-city model since these groups correspond exactly to the owners of developed and undeveloped land. However, there is a new group of losers in such a model, namely consumers, whose utility is lowered at all dates following imposition of the control. This is a consequence of the increase in urban land rents that follows from spatial constriction of the city.

With a new group of losers present, it appears that the political basis for growth controls is much weaker in the closed-city model than in the amenity-based open-city framework. Indeed, as described, the closed-city model seems unsatisfactory as a framework for the analysis of growth controls. This verdict would change, however, if the assumption of absentee landownership were altered. If landlords were instead to live in the city, then the share of the renter class in the urban population would be reduced and the political opposition to growth controls diluted. With the cost of occupancy (i.e., mortgage payments) fixed for the owners of developed land but with current land rents (and hence values) increasing under the growth control, the landowner portion of the urban population would benefit from such a law.[20] If it were large enough, this group could enforce its will at the ballot box against the opposition of renters and the owners of undeveloped land. Although the amenity aspects of growth controls are absent from this model, it might yield further useful insights.

7. Conclusion

Interest in the impact of growth controls on land values has generated a host of empirical studies. The literature, however, offers no formal analysis of this issue. To remedy this omission, the present paper has analysed the impact of growth controls in an open-city model similar to that of Capozza and Helsley (1988). The paper offers a number of insights, the most important of which is that growth controls in an amenity-based model may raise rather than lower the value of undeveloped land in some locations. More generally, the paper shows how to construct a simple yet realistic framework for the analysis of growth controls.

Tasks for future research could include analysis of the modified closed-city model discussed above. In addition, it might be useful to explore a variant of the open-city model in which the city imposing the growth control is "large" relative to the rest of the economy. In this situation, the diversion of population caused by the control would be great enough to depress the utility level in other cities. This welfare loss (which would also occur within the controlled city) would count as an additional cost of the control. This type of model might be especially relevant for regions like the San Francisco Bay Area where the widespread use of growth controls undoubtedly leads to a general equilibrium impact on consumer welfare.

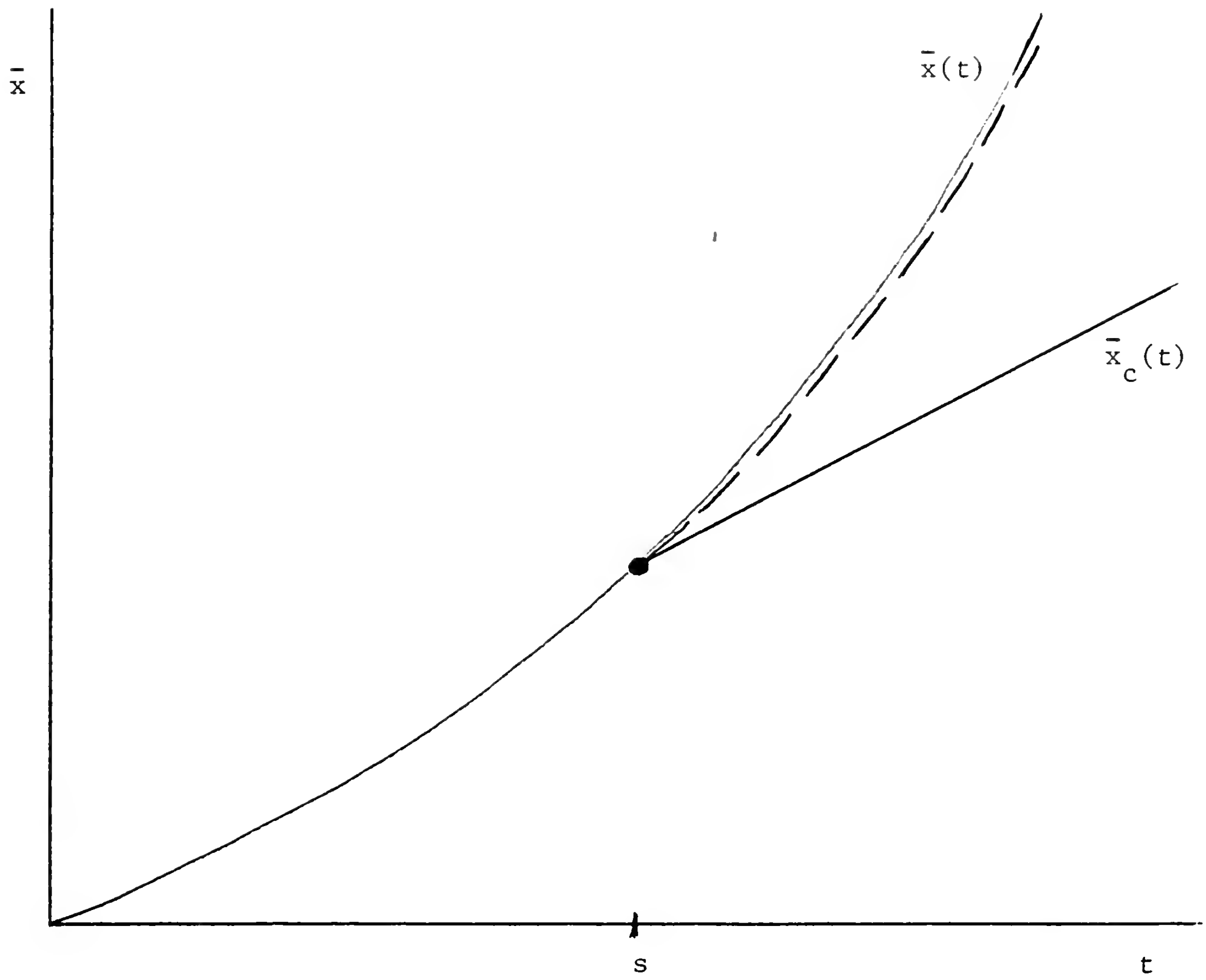
$\bar{x}$
$\bar{x}(t)$
$\bar{x}_c(t)$
s
t

Fig. 1

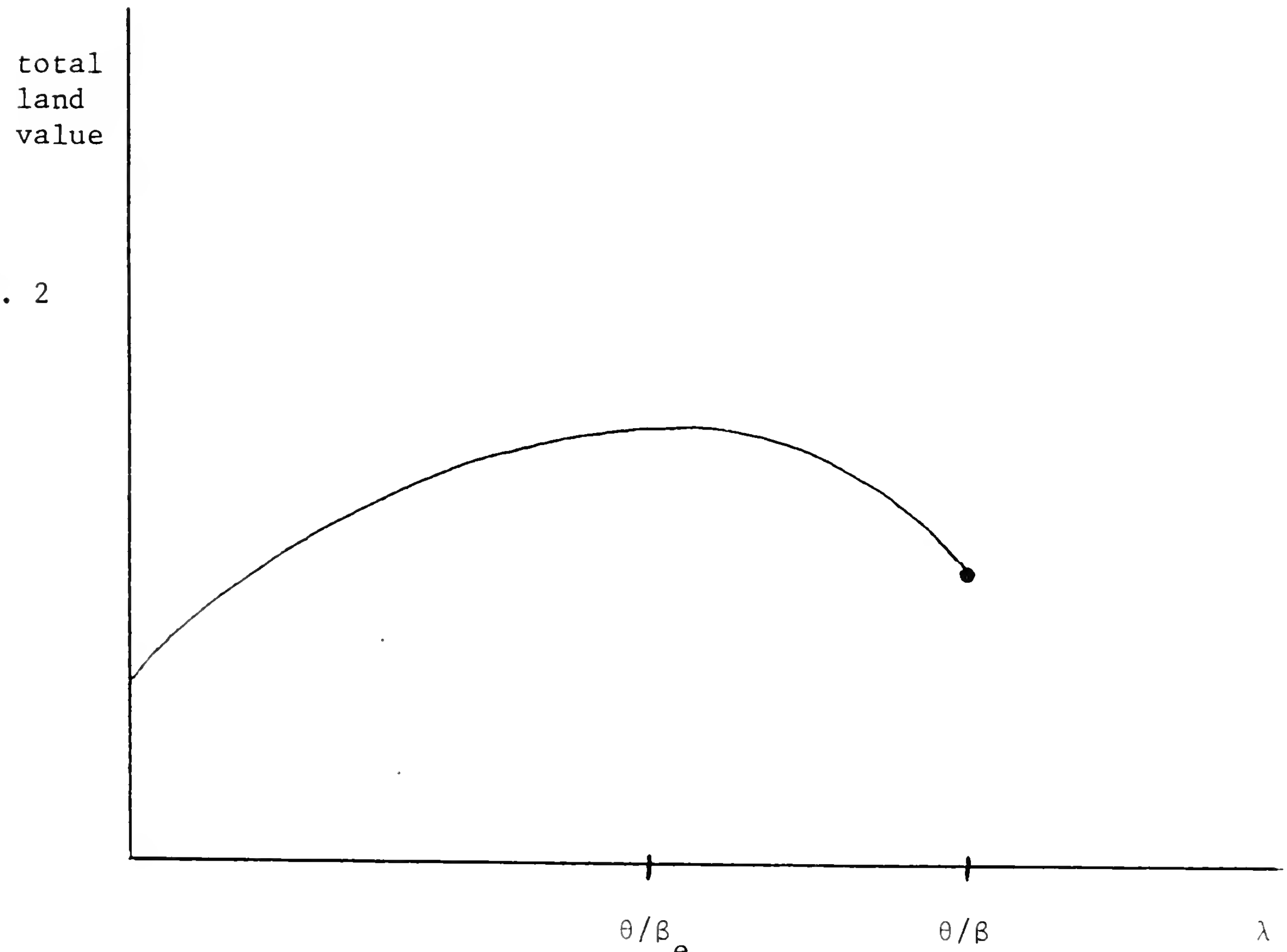
total
land
value
θ/β_e
θ/β
λ

Fig. 2

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Footnotes

*I wish to thank Perry Shapiro and Jon Sonstelie for helpful discussions of some of the issues considered in this paper. Kangoh Lee also provided helpful comments. Errors or shortcomings, however, are my responsibility.

[1] For an exhaustive and engaging survey of the empirical literature on growth controls and zoning, see Fischel (1989).

[2] Higher development fees can also raise prices as they are passed on to consumers.

[3] There have been few previous attempts in the literature to model growth controls. Cooley and LaCivita's analysis (1982) depicts the choice of optimal city size in a static model. Sheppard (1988) analyses the effect of restricting the land area available to various classes of consumers in a static multi-class city. By conducting static analyses, both of these papers omit key dynamic elements of the growth control problem.

[4] Like the commuting cost parameter k, r_a and D are assumed to be constant over time. All of these parameters could be made functions of time without affecting the conclusions of the analysis.

[5] From above, this requires that $dr(t,x,P(t))/dt = r_t + r_P P'(t) > 0$ holds at $t = T(x)$. Noting that $P'(t) = 2\pi\bar{x}(t)\bar{x}'(t)$, and substituting the above expression for $\bar{x}'(t)$, the second-order condition reduces to $r_t r_x/(r_x + 2\pi\bar{x}r_P) > 0$, which holds as long as $r_t > 0$.

[6] The first claim follows because $r_{Px} = r_{xP} = \partial(-k)/\partial P = 0$. The temporal behavior of r_P is uncertain because the total derivative $dr_P(t,x,P(t))/dt$ is ambiguous in sign.

[7] Note that r_P may fall to zero at a given t and x as population declines from P(t) to $P_c(t)$. Since r_P starts out negative, however, it must be the case that (6) exceeds (5).

[8] $V(T,x,s|\pi\bar{x}^2)$ is gotten by subtracting $\int_0^s r_a e^{-it}dt$ from $V(T,x,0|\pi\bar{x}^2)$ and multiplying by e^{is}.

[9]Note that this definition does not rule out discontinuities in $T_c(x)$ away from $\bar{x}(s)$ (or equivalently, flat ranges in $\bar{x}_c(t)$ away from $t = s$). The presence of such discontinuities does not affect the results derived below.

[10]Note that for the purposes of this calculation, the function $T_c(x)$ is assumed to be differentiable.

[11]With a change of variable from x to t, (14) becomes

$$\int_0^\infty 2\pi\bar{x}_e(t)\bar{x}_e'(t)De^{-it}dt$$

Integrating the above expression by parts assuming $\bar{x}_e(0) = 0$ yields (15).

[12]The second-order condition requires that

$$r_x + 4\pi\bar{x}_e r_P + \int_0^{\bar{x}_e} 4\pi^2 x\bar{x}_e r_{PP} dx < 0.$$

This condition is assumed to hold (note that satisfaction of the condition is guaranteed if $r_{PP} < 0$, indicating that rent decreases at an increasing rate with population).

[13]Strictly speaking, this inequality holds at values of t where $\bar{x}_e(t) < B$. For larger t's, equality holds.

[14]If r is twice continuously differentiable, then $\bar{x}_e(t)$ must be differentiable. Given that $\bar{x}_e'(t) = \bar{x}'(t) > 0$ for $t \le s$, $\bar{x}_e'(t)$ cannot be zero immediately after s without violating differentiability.

[15]The qualification stated in footnote 13 applies here.

[16]An attempt was made to investigate the spatial pattern of land value impacts under a linear control using the above example. Unfortunately, much of the ambiguity encountered in the general case remained.

[17]As usual, this outcome requires a prior assignment of property rights. The natural assignment gives landowners the right to develop their land unless persuaded to do otherwise.

[18]See Kim (1989) for an analysis of the closed-city version of the Capozza-Helsley model used in this paper.

[19]Land consumption must be endogenous in this model rather than being fixed at unity.

[20]Note that a complication in analysing this model is that the income of urban residents is no longer endogenous (landowners' income depends on endogenous urban rents).

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