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Alternative Land-Use Policy Tools for Green Area Preservation in Regional Development

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ALTERNATIVE LAND-USE POLICY TOOLS FOR GREEN AREA PRESERVATION IN REGIONAL DEVELOPMENT

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Preface

This paper is the third in a series on 'Regional Development and Land-Use Models'. The purpose of this series is to consider the application of optimizing and behavioural land-use models as tools in the study of regional development. The present paper considers some alternative policy tools for green area preservation within the context of a society with a competitive land market. A simple spatial equilibrium model is used to identify some social conditions under which certain kinds of tools would be effective. The paper is viewed as the first in a collection on models of land-use tool efficiency; an important research area identified in (1).

J.R. Miron
April, 1976

PAPERS IN THE REGIONAL DEVELOPMENT AND LAND-USE MODELS SERIES

(1) John R. Miron, "Regional Development and Land-Use Models; An Overview of Optimization Methodology", RM-76-27. April, 1976.

(2) Ross D. Mackinnon, "Optimization Models of Transportation Network Improvement: Review and Future Prospects", RM-76-28. April, 1976.

(3) John R. Miron, "Alternative Land-Use Policy Tools for Green Area Preservation in Regional Development", RM-76-29. April, 1976.

Abstract

Alternative land-use policy tools to effect green areas in a competitive market economy are investigated in this paper. A spatial equilibrium framework is used to identify and examine alternate tools. Specific conditions are derived under which such tools might operate effectively. While not providing immediate policy advice, such models indicate the kinds of variables and conditions which would be important to measure in an applied planning model.

ALTERNATIVE LAND-USE POLICY TOOLS FOR GREEN AREA PRESERVATION IN REGIONAL DEVELOPMENT

John R. Miron

Land use planners in many market-economy countries have been intrigued by the possibility of creating suburbs which are spatially distinct from each other and from their metropolitan cores. Policies have been promoted in this regard to protect large-scale 'green areas' which might act partly as a visible buffer or separator between urban areas throughout a metropolitan region. However, serious complaints about such green area policies are that (i) they are very expensive to implement if the government wishes to pay compensation, and (ii) they impose inefficiencies by forcing greater inter-area travel and commuting costs.

There are alternatives, on the other hand, to a policy instrument consisting only of legislated green areas. These may be capable of producing green areas as a simple consequence of competitive market behaviour and thus might eliminate the need for compensation. Further, to the extent that residents have the choice of locating in them, the existence of green areas in such areas might not represent an inefficiency in resource allocation[1].

A spatial equilibrium framework is a useful way of looking at the alternative instruments open to planners. It is helpful not only in the identification of alternatives but also in an analysis of the conditions under which such instruments might be effective. In this paper, the elementary closed version of the spatial equilibrium model, as formalized by Wheaton (1974), is used initially to identify four alternatives. Two of these instruments are then analyzed in detail with the aid of similar, specific models. Exact conditions are derived from these models for particular situations under which the effectiveness of these instruments is diminished. Such conditions, while qualitatively ambiguous, indicate the kind of empirical measures that planners have to make in justifying their choice of instrument.

1. The Elementary Closed Model

1.1 Assumptions and Solutions

Wheaton (1974) has dealt formally with the comparative statics of the elementary closed spatial equilibrium model. He did not, however, clearly spell out the assumptions underlying such models. There appear to be at least sixteen assumptions necessary and these are as follows.

i) Two sets of actors are identified; landowners and residents.

ii) The landowners are assumed to be non-collusive although each attempts to maximize the rent received for his parcel of land.

iii) Each landowner is assumed to own a 'small' parcel of land so that he is unable to behave monopolistically.

iv) Further, each is assumed to reside and spend his rental income outside the region in question.

v) The existence of N residents is assumed[2].

vi) Each resident earns the same income, Y, at the same central workplace, C.

vii) Each has an identical utility function, U, which defines convex preference orderings over combinations of two goods; land for a residence (L) and a composite (X).

viii) The composite good is available at a fixed price, P_x.

ix) Both goods have positive income effects.

x) Each individual can purchase any combination of these two goods provided that his total expenditures on these plus his commuting costs to work do not exceed his income.

xi) The commuting cost is assumed further to be proportional to distance.

xii) Each resident is assumed to have a choice of residential location with respect to his worksite and can re-locate costlessly.

xiii) The resident chooses a consumption bundle (consisting of his location, lot size, and composite goods level) to maximize utility subject to his budget constraint and to the constraint that his bid rent for that site be at least as large as the next highest bid.

xiv) It is assumed that there are enough residents that each behaves competitively and does not collude with others.

xv) It is further assumed that a long-run equilibrium exists in which no resident finds it advantageous to alter his location-consumption bundle.

xvi) Finally, the existence of an alternative non-urban user for all land at a fixed rent per unit area, R_a, is assumed.

These assumptions are typically sufficient to generate a set of equilibrium bid rents for land which decrease monotonically with distance from C. As is well known, the rate of decrease of rents with distance reflects the marginal rate of substitution between land and the composite good. Whatever this rate of substitution, the monotonically declining bid rents of residents together with the fixed rent bid of the non-urban use are sufficient to ensure that (i) all residents will reside within some minimum finite distance, ℓ_c, from C and (ii) no land will be allocated to the non-urban use at distance s where $s < \ell_c$. In other words, the equilibrium bid rent function of residents, R(s) will be greater than or equal to R_a for $s \leq \ell_c$ and less everywhere else. If we equate an occurrence of the non-urban land use with a green area, this implies that no green area buffers will occur within the city.

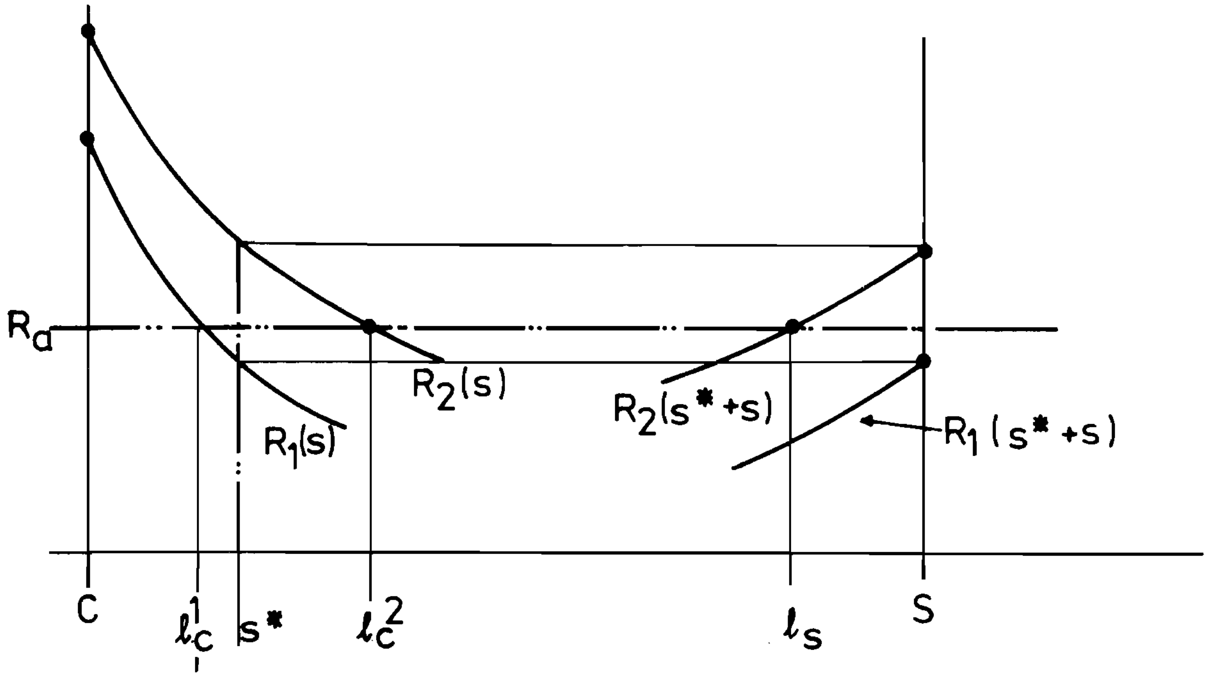
Another derivable implication of this model is the positive correspondence between the Ricardian rent at any location and city size, N. As N is increased, two adjustments take place. First, the physical area of the city tends to increase (i.e., ℓ_c increases). Secondly, the equilibrium land rents at each point within the city must also increase. The rent at the new boundary is R_a so that rent at the old boundary and at every other point in the city must increase to preserve the utility equilibrium of residents. With other parameters fixed, this additionally implies that the utility level of a resident decreases with increasing city size[3].

1.2 Alternative Instruments

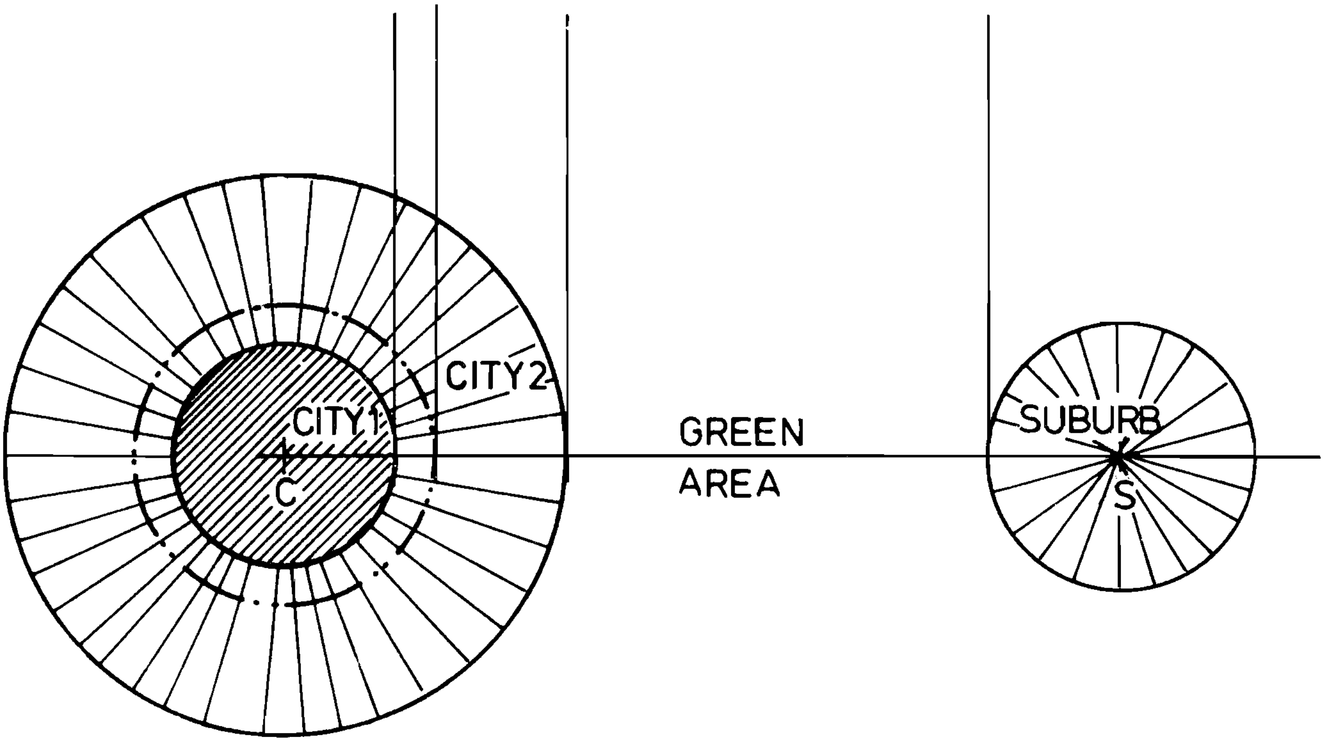
There are at least four ways in which the above assumptions might be generalized to permit a non-urban land use to occur within s* distance of C. The first is to suppose that the non-urban land use is capable of offering a variable land rent. If R_a is a function of location, it is conceivable that some non-urban land use may occur closer to C than the furthest urban resident. As is well known such an occurrence usually depends on local differentials in either soil fertility or other resource endowment. Such differentials are difficult to plan for and the urban planner does not often find such a ready-made green space exactly where he needs it.

A second alternative concerns the nature of the commuting cost function. Planners can, using the instrument of transportation system design, create a spatially discontinuous commuting cost function. Consider the following application of this approach. Replace assumption xi) by the following set of assumptions. A transportation link from C to a point S is constructed to which access is via C or S only. The only other mode of transport has a distance-proportional cost. Assume finally that the cost of travelling s* kilometres via this other mode is equal to the cost of travelling the new link from S to C.[4]

The spatial pattern of land use can now be investigated using Figure 1. If the city is small enough that its radius is less than s*, it will occupy only a circular area around C. This is the case of the bid rent function R_1 in Figure 1



a.) RICARDIAN LAND RENTS BETWEEN C AND S



b.) SPATIAL PATTERN OF LAND USE

FIGURE 1. RICARDIAN LAND RENTS AND THE SPATIAL PATTERN OF LAND USE WITH DISCONTINUOUS COMMUTING COSTS. AN EXAMPLE.

where the city's radius is ℓ_c^1. As the city becomes larger, its radius may extend past s^* . As it does, location around S becomes viable. In the case of the bid rent function R_2. the residents occupy a circle of width ℓ_c^2 around C as well as another circle of radius ℓ_s around S.

This instrument is one commonly used by planners. Moderate and high speed rail links are a good example of transportation facilities without intermediate access. It is noted in passing that the continuing growth of population should eventually lead to a convergence of the urban rings centered around C and S and the disappearance of the green area buffer.

Another instrument which planners might use to encourage green area buffers involves the decentralization of jobs. In the elementary model, everyone is assumed to work at a point C. In the context of Figure 1(b), the planners might be interested in policies which result in a re-allocation of some jobs from C to S^1 with a corresponding movement of residences. Given that jobs can be relocated, we might inquire about the conditions under which residences follow. There might exist, for example, a situation in which the attraction of residing in a central city outweighs the cost of commuting to a job in the suburb. In such a case, residences may not follow jobs to the suburb. A spatial equilibrium model, from which is derived a simple statement about the occurrence of such a trade-off, is developed in Section 2 below.

If jobs are not to be relocated from C, something else must be provided to attract residences away from the central city. The basis for a final instrument is therefore to provide at or near S an amenity or service which residents desire and which has no immediate substitute closer to C. The presumption is that this would attract residents to S even if all jobs remain at C. A specific model in which such an amenity is embedded is discussed in Section 3 below.

2. A Suburb Model with Decentralized Employment

2.1 New Assumptions

Begin by making the following changes to the assumptions outlined in Section 1.1 above. Amend vi) to assume two points in space, C and S, at which all jobs are concentrated. These could be thought of as the centres of a central city and a suburb. Assume that there are N_c and N_s jobs at C and S respectively where

$$N = N_c + N_s \quad . \qquad (1.a)$$

For simplicity assume that all jobs have the same wage and that the distance-marginal cost of commuting is the same regardless of the centre, C or S, to which a residence commutes. It is assumed that C and S are separated by a distance of d kilometres and trivially that the annual cost of commuting this distance does not exceed the worker's income level. Next, the good X as described in assumption vii) is assumed to be available only at C.[5] All residents must travel to C to acquire this good regardless of where they work. Further, a separate trip to C is required for each unit of X consumed. This good might, for example, be a specialized service or a central city amenity. All residents are assumed to be willing to forego something to acquire some amount of it. Also, amend viii) to assume that X is available at a unit price, P_x, at C to which each resident adds a fixed distance-proportional travel cost from his residence site. This effective price, P(r), for a resident at distance 'r' from C is defined as follows.[6]

$$P(r) = P_x + tr \tag{1.b}$$

2.2 The Model and its Solution

The above assumptions lead to an immediate conclusion. Those residents who work at C will themselves have the same equilibrium behaviour found in the elementary model. The S-workers however, are also attracted to C and it is their behaviour which deviates from that of the elementary model. For the moment therefore, attention is placed solely on these suburban workers.

The S-worker selects a residential site keeping in mind its proximity to both C and S. As illustrated in Figure 2,

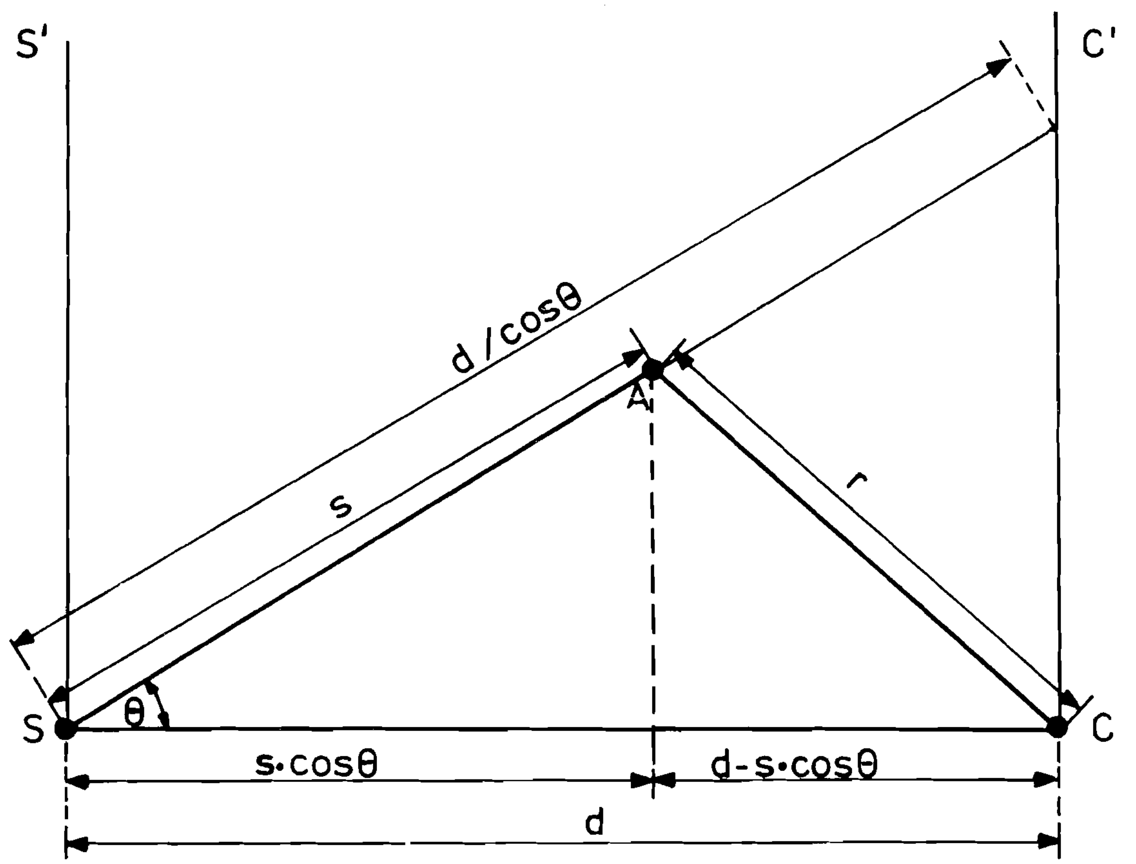


FIGURE 2. SPATIAL ASPECTS OF THE SUBURB MODEL

consider a site A at 's' kilometers from S and at an angle θ. That site will be $r(s,\theta)$ kilometres from C where

$$r(s,\theta) = \sqrt{d^2 + s^2 - 2ds\cdot\cos\theta} \quad . \tag{1.c}$$

The utility function, budget constraint, and first-order maximization conditions for an S-worker can now be defined and found. A log-linear utility function is assumed.

$$U_s = X^{\alpha} L^{1-\alpha} \qquad (o < \alpha < 1) \tag{1.d}$$

U_s is maximized subject to a budget constraint of the following form[7].

$$Y = cs + R_s(s,\theta)L + [P_x + tr(s,\theta)]X \quad . \tag{1.e}$$

The familiar first-order conditions are

$$R_s(s,\theta)L = (1 - \alpha)[Y - cs] \tag{2.a}$$

$$[P_x + tr(s,\theta)]X = \alpha[Y - cs] \tag{2.b}$$

Substituting these back into (1.d) yields an optimized utility function, $\tilde{U}_s$.

$$\tilde{U}_s = [Y - cs]\; B[P_x + tr(s,\theta)]^{-\alpha}\; R_s(s,\theta)^{-(1-\alpha)} \tag{2.c}$$

where

$$B = \alpha^{\alpha}(1-\alpha)^{1-\alpha} \quad . \qquad (2.d)$$

The existence of a utility equilibrium through space implies that (2.c) can be reversed to generate the equilibrium Ricardian rent associated with the site (s,θ).

$$R_s(s,\theta) = \frac{[B/\tilde{U}_s]^{1/(1-\alpha)}[Y-cs]^{1/(1-\alpha)}}{[P_x + tr(s,\theta)]^{\alpha/(1-\alpha)}} \qquad (2.e)$$

In a similar manner, the equilibrium bid rent of a C-worker at 'r' kilometres from C can be found[8].

$$R_c(r) = \frac{[B/\tilde{U}_c]^{1/(1-\alpha)}[Y - cr]^{1/(1-\alpha)}}{[P_x + tr]^{\alpha/(1-\alpha)}} \qquad (2.f)$$

2.3 Interpretation

Several observations can be made about the bid rent function of S-workers. First, $\tilde{U}_s$ is as yet an unknown. Its value depends on (i) the number of S-workers to be located and (ii) the spatial pattern of competing land uses[9]. Secondly, although $\tilde{U}_s$ is not known, it is apparent that it does not affect the relative rent bids of S-workers. The spatial pattern of rent bids is fixed in that the ratio of their bid rents at any pair of locations is independent of $\tilde{U}_s$. Thus, $\tilde{U}_s$ affects only the absolute scale of rent bids.

Thirdly, attention may be concentrated on a particular portion of the s-θ space in analyzing $R(s,\theta)$. It is apparent for example that R is symmetric about the line SC since $R_s(s,\theta) = R_s(s, 2\pi - \theta)$. This permits us to concentrate solely on that portion of land sites lying above SC in Figure 2. Further, our interest in the buffer role of green areas directs our attention specifically to the area between C and S. Therefore, the behaviour of $R(s,\theta)$ need be examined only in the space $0 \leq \theta \leq \pi/2$ and $0 \leq s \leq d/\cos\theta$. This corresponds to the area framed by S'SCC' in Figure 2.

Fourthly, the spatial pattern of $R(s,\theta)$ within this area can be determined. We begin by asking whether $R_s(s,\theta)$ has any local stationary points. These are found from the two first-order conditions, (3.a) and (3.b).[10]

$$\partial R_s(s,\theta)/\partial\theta = \left[\frac{\alpha}{1-\alpha}\right]\left[\frac{R_s(s,\theta)}{P_x+tr}\right]\left[\frac{td}{r}\right] s\cdot\sin\theta = 0 \quad (3.a)$$

$$\partial R_s(s,\theta)/\partial s = R_s(s,\theta)\cdot g(s,\theta)\cdot h(s,\theta) = 0 \quad (3.b)$$

where

$$g(s,\theta) = [(1-\alpha)(Y-cs)(P_x+tr)]^{-1} > 0 \quad (3.c)$$

and

$$h(s,\theta) = \alpha(Y-cs)\, t(d\cdot\cos\theta - s) - c\cdot r\cdot(P_x+tr) \quad (3.d)$$

One solution to (3.a) is to set $\theta = 0$. Thus, from (3.b), we must have $h(s,0) = 0$ which holds when $s = s^*$ where

$$s^* = \frac{c(P_x + td) - \alpha tY}{(1 - \alpha)ct} \qquad (4.a)$$

Thus, if $0 \leq s^* \leq d$, a local internal extreme point is $(s^*,0)$. Further, a simple re-arrangement of $h(s,0)$ yields

$$h(s,0) = [d-s][t\alpha Y - c(P_x+td) + (1-\alpha)cts] \qquad (4.b)$$

Thus, $h(s,0)$ and $\partial R_s/\partial s$ (at $\theta = 0$) are negative for s less than s^* and positive for it greater than s^*. The extreme point $(s^*,0)$ can thus be shown to be a minimum along the ray $\theta = 0$.[11]

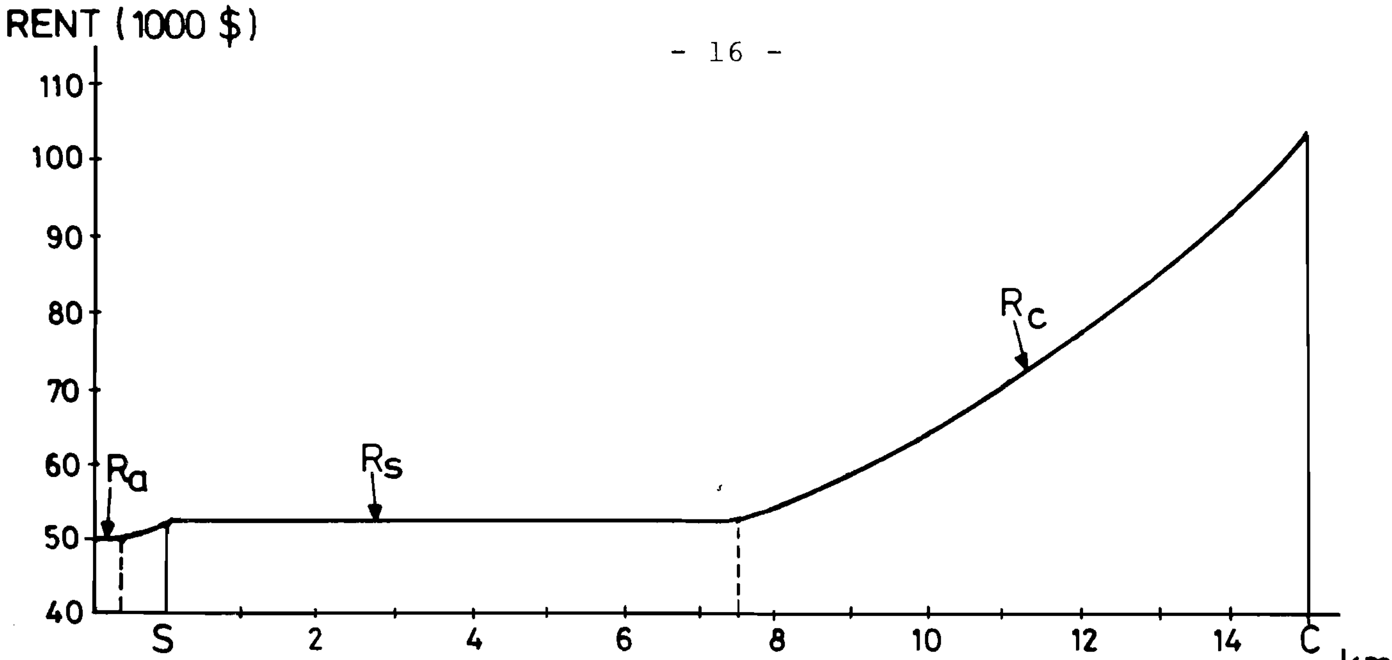
A conventional first case, often hoped for by planners, occurs when $s^* > d$. This implies, using (4.d), that the bid rents of S-workers are a monotonically-declining function of distance from S. In this case, the S-workers locate around that point with a suburban boundary $\ell_s(\theta)$ which depends on θ (it is not circular in general)[12]. For any distance $s < \ell_s(\theta)$ along the ray θ, no land will be occupied by green areas. Provided that N_c and N_s are small enough relative to the separating distance, d, a green area will emerge between C and S.

The condition $s^* > d$ itself simplifies to the following:

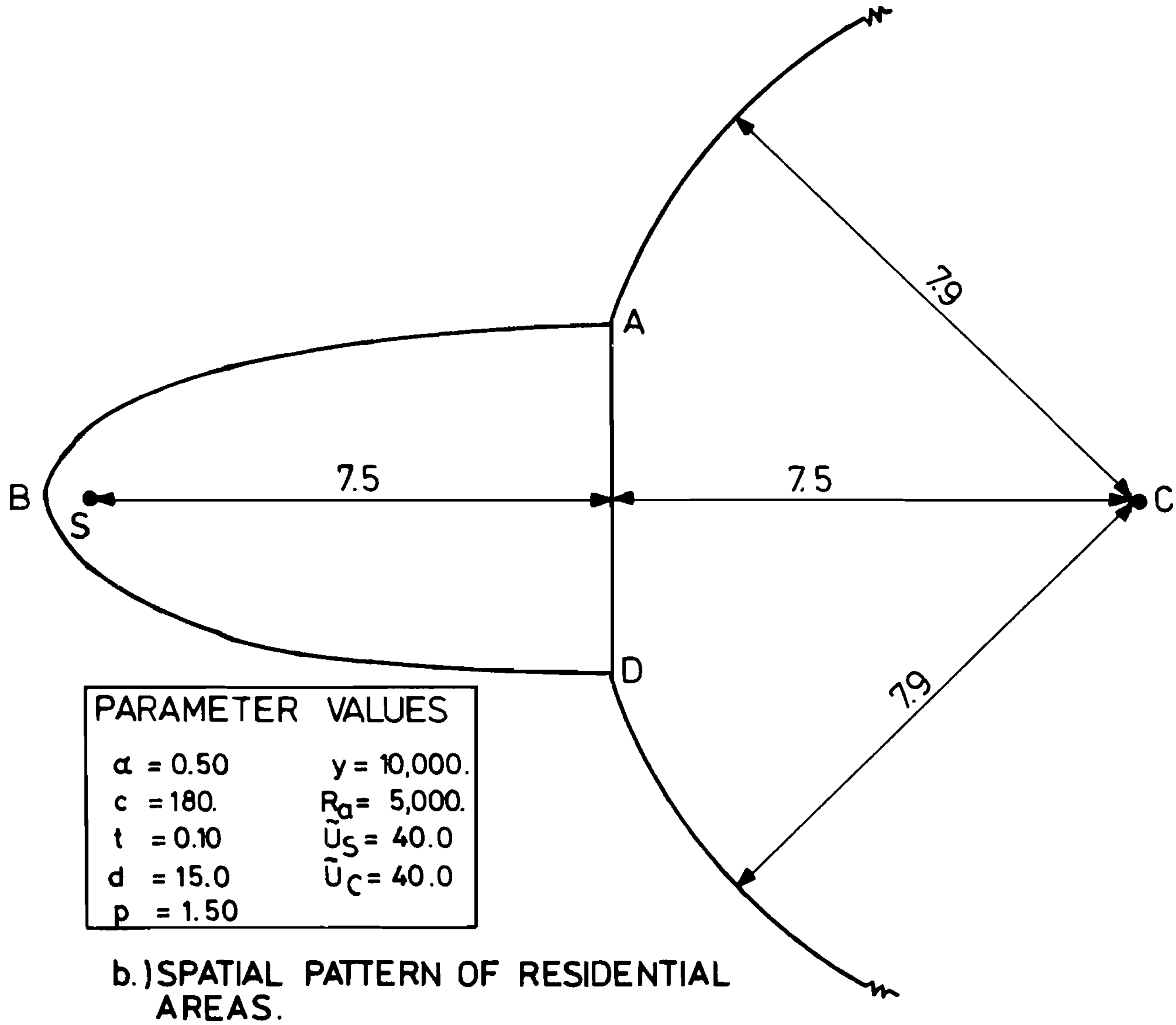
$$t\left[\frac{\alpha(Y-cd)}{P_x}\right] < c \qquad (5.a)$$

The term $\alpha(Y\text{-}cd)/P_x$ represents either the number of units of X consumed annually by an S-worker residing at C or the number of trips taken to consume X. The left hand term of (5.a) represents the incremental cost in consuming that amount of X if the worker moves a unit distance away from C. Thus, (5.a) asserts that for the conventional case to hold it is sufficient that, for a S-worker resident at C, the incremental annual trip costs in consuming X by moving one unit distance closer to S be less than the incremental saving in annual commuting costs associated with that move. Thus, (5.a) is based on the relative size of transportation cost increments evaluated at the point C.

An unconventional second case emerges when $s^* < 0$. This implies that $R_s(s,\theta)$ is an increasing function of distance from S in the area between C and S for small values of θ. Thus, S-workers would have a tendency to locate near C rather than S. The specific locational pattern in equilibrium depends on the alternative land rent bids by all three groups (S-workers, C-workers, and agriculture) but S-workers will tend to locate in an enclave at the edge of the area occupied by C-workers and this may or may not include the point S. An example is presented in Figure 3 which illustrates that no green area will emerge between the residential areas of C- and S-workers. Planners who rely on the job-decentralization instrument are therefore interested in empirically evaluating s^* to ensure that this unconventional case does not occur.



a.) RENT LEVELS ALONG SC RAY. (θ = 0)



b.) SPATIAL PATTERN OF RESIDENTIAL AREAS.

FIGURE 3. SUBURB MODEL LAND RENTS AND LAND USE: AN EXAMPLE.

The condition $s^* < 0$ can also be lent an interpretation. It asserts the following

$$t\left[\frac{\alpha Y}{P_x + td}\right] > c \tag{5.b}$$

This means that an S-worker resident at S must find that the annual saving in the cost of acquiring X by moving one unit closer to C must more than offset the increase in annual commuting costs associated with moving one unit further away from S. This condition again trades off relative transportation cost increments but now at the point S. It states a specific sufficient condition under which a green area buffer would not arise.

Finally, consider the third case in which $0 \leq s^* \leq d$. This implies that $R_s(s,\theta)$ is a saddle-shaped function with maxima at $R_s(0,0)$ and $R_s(d,0)$. Several locational patterns are possible depending on (i) the size of $R_s(d,0)$ relative to $R_s(0,0)$ and (ii) the magnitude of N_s relative to N_c, d, and R_a. Possible solutions include (i) all S-workers located near S, (ii) all located adjacent to the residential area of C-workers, (iii) two colonies of S-workers at S and near C separated by a green area buffer, and (iv) one residential area for S-workers adjacent of that of C-workers but also including S.

An example of this solution is presented in Figure 3. Here $s^* = 4.44$ which is less than the 15.0 value for 'd'. $R_s(s,\theta)$ is u-shaped along $\theta = 0$ although its curvature is imperceptible along the section displayed in 3(a). C-workers occupy the best part of a circular area of 7.9 kilometres radius and S-workers occupy an area ABD as shown in Figure 3(b).[13] Thus, this is an example of the third case in which no buffer area exists between city and suburb.

3. A Model with Suburban Amenities

3.1 New Assumptions

The rationale behind this last model is that planners provide an amenity at or near S which is not available at C. This amenity is provided here without an accompanying provision for jobs to clarify the conditions under which an amenity alone is sufficient to create a nucleated suburb. The amenity provided will be called a 'beach' although the name is merely a convenience. This beach is assumed to run perpendicular to the line CS through S and that each resident is indifferent as to where along the beach he consumes its amenity value. Further, location is assumed to be feasible only on the near (to C) side of the beach.

The assumption set of the elementary model is modified as follows: In assumptions vii) to ix), the good X is assumed to be the number of beach visits made by a resident each year. The good X is assumed to be undertaken at a fixed cost of P_X per visit[14]. In addition, each trip incurs a travel cost which is proportional to the distance from the beach to the resident's home site. As illustrated in Figure 4, a resident at (s,θ) is r kilometres from the beach where

$$r(s,\theta) = d - s \cdot \cos\theta \qquad (6.a)$$

Thus, the total cost of a trip to the beach for this resident is, $P(s,\theta)$ where

$$P(s,\theta) = P_x + tr(s,\theta) \qquad t > 0 \qquad (6.b)$$

3.2 The Model and its Solution

This model has been deliberately designed to be quite similar to the previous model in notation and structure. Part of the purpose in doing this has been to illustrate how a very simple model can be interpreted in different ways to answer different kinds of questions. We use the same equations for the utility function and budget constraint as before[15]

$$U = X^{\alpha} L^{1-\alpha} \quad , \qquad (7.a)$$

$$Y = cs + R(s,\theta) L + [P_x + tr] X \quad . \qquad (7.b)$$

The same first-order conditions emerge, namely

$$R(s,\theta) L = [1-\alpha][Y-cs] \qquad (8.a)$$

$$[P_x + tr] X = \alpha [Y-cs] \quad . \qquad (8.b)$$

Finally, the optimized utility level, $\tilde{U}$, can be derived

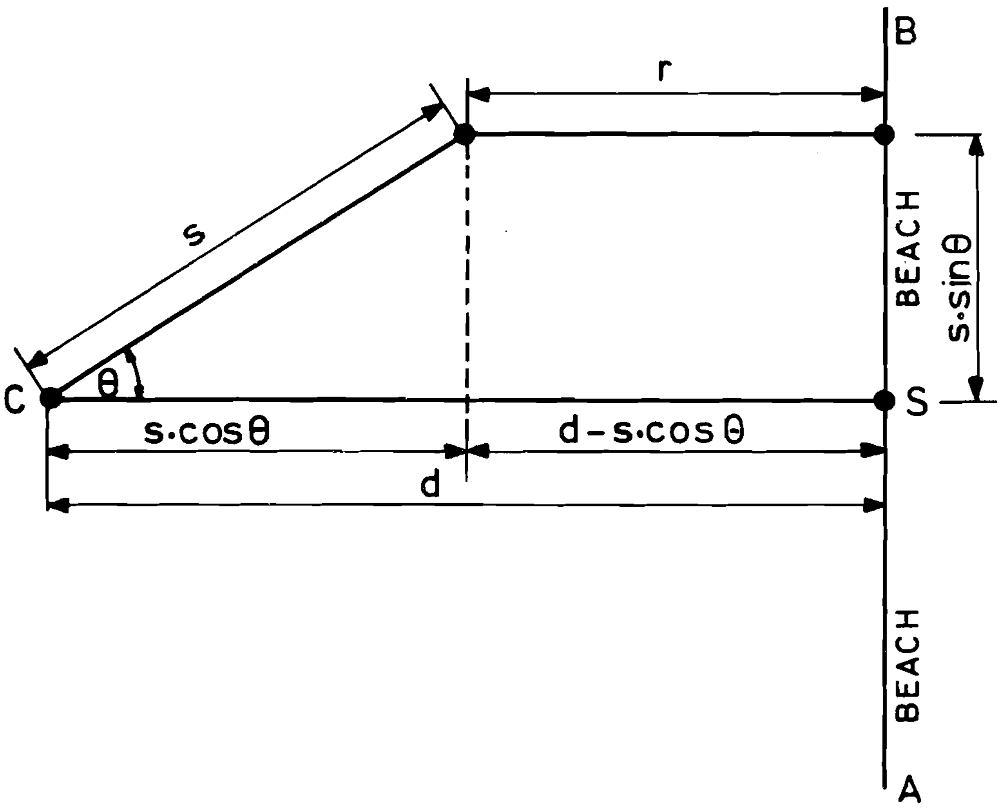


FIGURE 4. SPATIAL ASPECTS OF THE BEACH MODEL

and reversed to yield the equilibrium bid rent function, $R(s,\theta)$.[16]

$$R(s,\theta) = \frac{(B/\tilde{U})^{1/(1-\alpha)}[Y-cs]^{1/(1-\alpha)}}{[P_x + td - t\cdot s\cdot \cos\theta]^{\alpha/(1-\alpha)}} \qquad (8.c)$$

These rent bids differ from those of the previous model only because $r(s,\theta)$ is defined differently.

3.3 Interpretation

What planners usually hope to achieve in this situation is different from the previous one considered. In the earlier case, they encouraged the centralized location of residences near their decentralized jobs. In the present case, they are seeking to decentralize residences around centralized jobs. Thus, they are specifically interested in the conditions under which $R(s,\theta)$ would imply the existence of two residential areas, one near C and the other along the beach, separated by a buffer green area.

Such a situation can emerge only when $R(s,\theta)$ is double-peaked. For reasons similar to those in the last model, let us consider only the spatial area lying between C and S and for which $0 \leq \theta \leq \pi/2$. Internal extreme points of $R(s,\theta)$ are found by differentiating with respect to 's' and θ. One extreme point is at $(s^*,0)$ where s^* is defined, as before, by (4.a). It is easily shown that $R(s,0)$ is a decreasing function of s when $s < s^*$ and an increasing function when $s > s^*$. Thus, to have a dual peaked $R(s,\theta)$, it is necessary that $0 < s^* < d$. This implies that

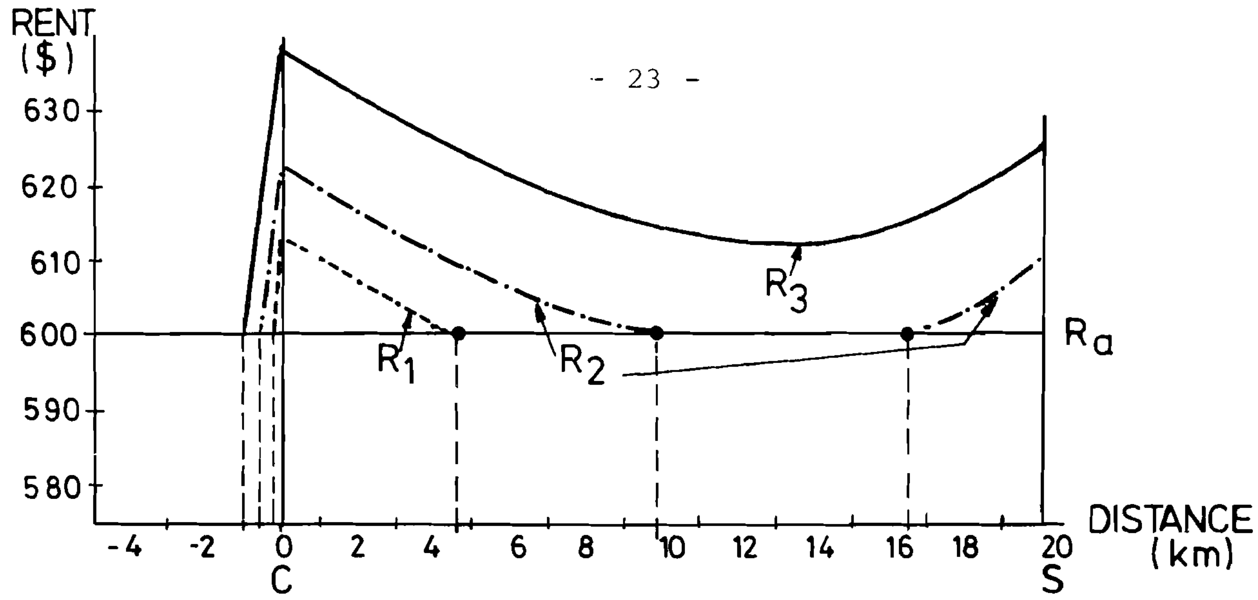
$$t\left[\frac{\alpha Y}{P_x + td}\right] < c \qquad (s^* > o) \qquad (9.a)$$

and

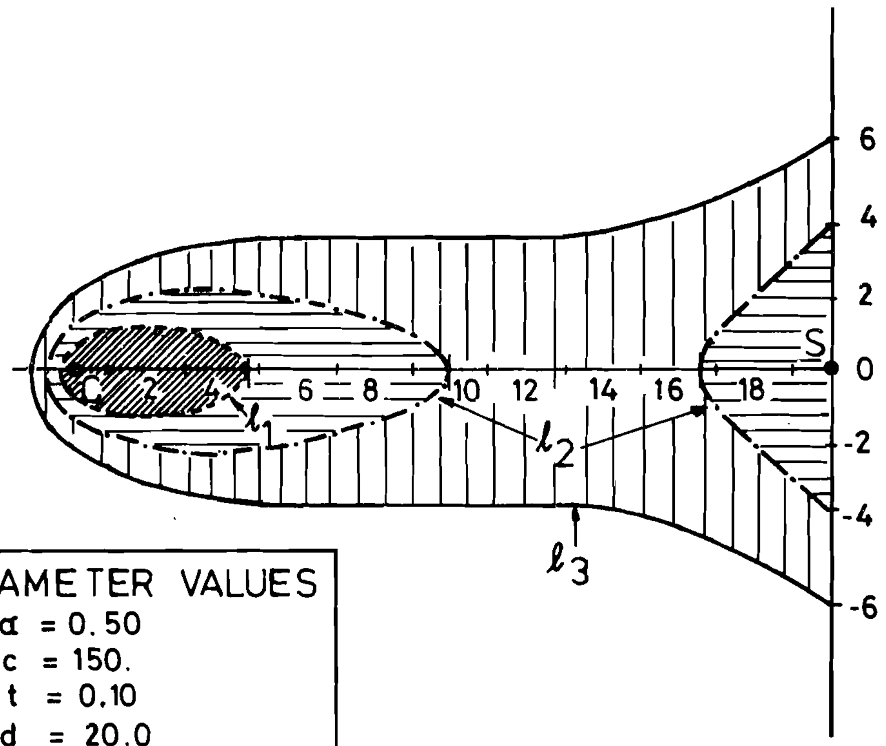
$$t\left[\frac{\alpha(Y - cd)}{P_x}\right] > c \qquad (s^* < d) \qquad (9.b)$$

Thus, two conditions must exist related to annual increments in beach travel and commuting costs with a marginal change in location along the line CS. The first states that for a resident at C, the beach travel cost increment be less than the commuting cost increment. The second asserts that the opposite be true for a resident at S. While it is difficult to conclude anything about the liklihood of both these conditions being satisfied, they indicate the kinds of variables which need to be estimated in an empirical study.

Conditions (9.a) and (9.b) are necessary though not sufficient to ensure the emergence of two residential areas. It is necessary, in addition, that d, N, and R_a be of appropriate size. An example is presented in Figure 5 to illustrate this. All parameters there are fixed at the levels shown except for $\tilde{U}$ which is given three different values to correspond to three different city sizes. In order of increasing city size, the bid rents generated are R_1, R_2,



a.) RENT LEVELS ALONG SC RAY (θ=0)



PARAMETER VALUES
α = 0.50
c = 150.
t = 0.10
d = 20.0
P_x = 2.00
R_a = 600.

b.) SPATIAL PATTERNS OF RESIDENTIAL AREAS.

FIGURE 5. BEACH MODEL LAND RENTS AND LAND USE: AN EXAMPLE.

and R_3 respectively in 5(a). Given the value of R_a, these imply that the residents would occupy an area enclosed by ℓ_1, ℓ_2, and ℓ_3 at these size levels. For the smallest city size, there is a single residential area near C. At a larger size we observe the city occupying two areas (one near C and the other near S) with a green space buffer between them. At the largest size, the city has grown to completely fill in the space between C and S as shown in 5(b).

It is noted that a dynamic pattern of suburban development is implied by Figure 5. The city begins around C and then reaches a threshold at which residential development begins at S even though there is vacant land between S and the previous urban fringe. Finally, all the land between C and S becomes filled in with residences as the city expands in size. However, the scheme illustrated in Figure 5 is only one of these possible cases where (9.a) and (9.b) hold. These cases depend on which of R(0,0) and R(d,0) is greater. In Figure 5, $R(0,0) > R(d,0)$ and development initially occurs only near C. If $R(0,0) = R(d,0)$, development will initially occur at both C and S and if $R(d,0) > R(0,0)$, it will occur first at S.

Finally, we observe that (9.a) and (9.b) are fairly stringent requirements on the parameters of the model because they must hold simultaneously. If only one of these conditions holds (and at least one must always hold), the model will generate monotonically declining rents around either C or S. In these cases no buffers will emerge. Thus, planners who rely on a suburban amenity instrument for the creation of buffer areas need to assure themselves that (9.a) and (9.b) both hold.

4. Conclusion

The purpose of this paper has been to show that a spatial equilibrium framework can be used to examine some alternative instruments for the creation of inter-urban green area buffers. Specific conditions have been derived under which such instruments might not operate effectively or at all. These have been generated using simple models with relatively similar structures. While not providing immediate policy advice, such models indicate the kinds of variables and conditions which are important to measure in a policy-oriented empirical model.

Footnotes

1. Whether legislated or competitively-induced green areas are or are not efficient depends in part on the magnitude of externalities created by such a land use pattern.

2. A resident is equated to a residence here.

3. Wheaton (1974; pp. 228-229) discusses this aspect of the closed model in a general form. Miron (1976) discusses these points for a particular model form.

4. It is assumed that S is more than s* kilometres from C.

5. This altered characterization of X need not reduce the generality of the original model. Another composite good (say Z), available everywhere at a uniform price, can be introduced without any significant theoretical effect on the remaining discussion.

6. The transportation cost component (tr) corresponds to the Varaiya-Artle (1972) notion of 'transaction cost'.

7. It is assumed that the utility levels of C- and S-workers may be different from each other. A utility differential may arise because of the difference between N_c and N_s even though incomes and prices (excluding rent) are identical for both.

8. Note that R_c is monotonically decreasing in 'r'. Note also that the bid rents of C-workers have no θ argument because they are indifferent to location with respect to S.

9. Including the bid rents of workers at C.

10. For simplicity of notation, $r(s,\theta)$ is denoted simply as 'r' below although it remains a function of s and θ.

11. Note that $(s^*,0)$ is more-generally a saddle point when θ is variable.

12. The boundary will tend to be egg-shaped with an apogee at $\theta = 0$.

13. The boundary between the C and S areas, when these two are adjacent, need not be a straight line. Equating (2.e) and (2.f) yields the boundary condition

$$r = [1-(\tilde{U}_c/\tilde{U}_s)][Y/c] + [\tilde{U}_c/\tilde{U}_s]s$$

which is a straight line only when $\tilde{U}_c = \tilde{U}_s$. With respect to S, it is convex if $\tilde{U}_c > \tilde{U}_s$ and concave if $\tilde{U}_c < \tilde{U}_s$.

14. This might, for instance, include the cost of lunches, sun-tan lotion, and parking in the case where the amenity is a beach in reality.

15. Again, we refer to $r(s,\theta)$ simply as 'r' while recognizing its dependence on s and θ.

16. Again, $\tilde{U}$ is an unknown whose value depends on N and R_a.

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