



Ground Rent in Distribution and Welfare Economics

By Dr. Mason Gaffney

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Chapter V

"Ground Rent in Distribution and Welfare Economics."
Fragment #3 of the preliminary draft for discussion at
seminar at Lincoln, Nebraska, June 16-23, 1961.

What follows is a development of the materials outlined as
section II of my outline of January 5 (Fragment #1). This
material is found on pp. 8-10 of that outline.

GROUND RENT AS INCENTIVE AND CONSTRAINT: THE ALLOCATIVE FUNCTION

A. Rent as Incentive vs. Rent as Surplus

Ground rent as an aggregate distributive share is a
"surplus", we have maintained, distinguished from other
distributive shares in that it does not serve the function
of evoking the aggregate supply of the input to which it
imputes.

Factor payments have, however, two functions. Besides
calling forth the aggregate supply they also serve to ration
or allocate it among competing uses. Rent serves the second
of these functions quite as much as do other shares. The
incentive to put land to its best use is to earn the high-
est rent, and--what is another aspect of the same thing--
the constraint against using land too disrespectfully is
the opportunity cost represented by the maximum attainable
rent.

B. Accepted Doctrine and Some of its Limitations

"Rent", wrote Ely and Wehrwein, "acts as the 'sorter'
and 'arranger' of this pattern (of land use.)" Rent
preempts the choicest sites for uses that have greatest
need of their advantages, and ranks land-uses in order
according to their rent-paying capacity.

The body of doctrine called location theory, as ad-
vanced by Thunen, Weber, Losch, Hoover, Dunn, Isard, and
others elaborates on this principle at length so that the
allocative function of rent may be regarded not only as
received but relatively advanced doctrine.

For all the attention the topic has received, however,
some quite important aspects have been neglected. Major
emphasis has been given to the function of rent in ranking
land uses in order of rent-paying capacity. Less attention
has been afforded the quantitative function of rent in
determining just how much land each firm and use can econ-
omically occupy; and still less attention to the social
rationale for the spatial constraint in terms of trans-
portation savings to other members of society whose

traversal costs are reduced by economy of land lying between them and their destinations. Which may be summed up in this, that location theory analyzes the influence of transport costs on land use but neglects the converse, the influence of land use on transport costs.

Location theory does, to be sure, tell us that individuals with greater demands on transport tend to locate centrally, thereby tending to minimize aggregate transport costs. This is important information. But transport costs also vary with the overall intensity of land use. For example if all land users, preserving their ordinal ranking, were to double their space occupancy they would increase both the miles they had to travel and in all probability the social cost per mile as well.

Clearly an important social function of rent is to constrain such expansion to the end of minimizing aggregate transport costs and maximizing productive linkages. Clearly, too, this is one of the more interesting questions in an era of rapidly increasing per capita space use both in urban and rural areas. But it is a question on which location theory, as developed thus far, gives us little guidance for evaluation or policy-making.

The major authors have in fact effectively blocked themselves from treating this question by setting transport rates outside the scope of their analysis. To a man they adopt the assumption that private transport rates accurately represent social costs. This is not to say that these economists allege the assumption to be true. It is rather the boundary beyond which they have chosen not to push their investigations, which is certainly any writer's privilege. But the fact that they have accepted this boundary is symptomatic of their neglect of the function of rent as a constraint on spatial extension. For to evaluate that constraining function one would have to analyze transport costs and show how they increase--not approximately but exactly--with increasing lot sizes.

For example suppose it be true (as in fact I believe it is) that private transport costs for all commodities--that includes utilities--at both rural and urban fringes were less than social costs. This would have only minor effects on the ordinal ranking of land uses, but it would tend to relax rental constraints on intramarginal lands below an economic level, and reduce intensity there. This in turn would disperse population wider and impose more transport costs on society. Thus peripheral transport subsidies would cause private adaptations via the medium of reduced intramarginal rents. The uneconomical burdens imposed on society by such subsidies are not simply the

obvious short run adaptations to fixed transport facilities, but also the long run relocation of population with demands for further extension of subsidized transport facilities. These are the effects of land use on transport costs. These are the matters neglected by location theorists. Are we sure that rent is an economical constraint on quantitative extension of land occupancy even in the absence of transport subsidy? Do we know enough about transport costs to say whether transport is subsidized or not? Would we know an economical pattern of transport rates if we met one walking down the street?

Probably no location theorist has neglected spatial extension so thoroughly as Alfred Weber and his disciples. His industrial locations are simply points. This would seem to preclude any very realistic analysis, because in fact industries are separated by space largely because they occupy space. In Weber's scheme this difficulty is overcome by arbitrarily dividing industries into "agricultural" ones which occupy space and others that do not. Curiously, the tradition has persisted so that even today "industrial" and "agricultural" location theory are treated as two separate studies.

To assume that urban industry occupies no space is equivalent to assuming that intra-urban transport is negligibly cheap, a point which every airline passenger can refute, if refutation be necessary. It is equivalent to assuming the study of city planning is an idle occupation, that Borden has no fleet of milk trucks and Los Angeles County is still covered with orange groves.

In fact while urban industries do occupy less space than agriculture they occupy much more valuable space, every foot of which lies in the way of much more traffic of people and commodities and utilities in the city's busy circulatory system. Moving from country to city the importance of economizing on space grows larger in the measure that space requirements grow less, and probably in greater measure because of the higher rate of turnover of capital on surrounding urban sites. The Weber tradition is therefore not just an oversimplification, it is positively misleading and probably opposite from the correct emphasis.

Weber's lack of appreciation for rent's space-constraining function was sufficiently profound to cause him to identify rent as a "deglomerative" factor, a social cost of congestion tending to drive people away from central places. It is true that high rents drive extensive land uses from central places, but they do so only to reserve the land for intensive uses. The force driving people from central lands is not rent, but scarcity of land. Rent, viewed as a constraint on the landholder, has the opposite effect:

it forces him to economize closely on land by using little per man, per room, and per unit of output.

The "agricultural" tradition in location theory, stemming from Thunen, does recognize the spatial extension of land uses. Intensive uses drive out extensive ones, resulting in concentric rings of land uses around market centers. Thunen's emphasis is however on the ordinal ranking of uses, not on intensity of use. Thunen was uninterested enough in intensity per se to assume that it was constant within each ring, despite higher transport costs at the outer boundary of each ring.

The assumption of fixed intensity might be a mere crudeness rather than a complete disqualification. Intensity does change from one ring to the next, and the rings could be made very small. But it is symptomatic of a lack of concern with effects of spatial extension on transport costs. Thunen's transport rates decline slightly with distance, without consideration to the economies realized by spreading fixed roadbed costs over more traffic in central places. The relation of the rental constraint to the economy of transport is not developed.

Losch elaborates on both Weber and Thunen but does not really free himself from their limiting assumptions. Losch's work on "industrial" location follows Weber's assumption of dimensionless plant sites. Losch's "agricultural" location theory emphasizes the ordinal ranking of land uses, with intensities invariant. He does not analyze the effect of intensity on transport costs.

Dunn and Isard score a major advance over the German schools by introducing continuous variability of intensity into their analyses. They perpetuate the idea that there is something peculiarly "agricultural" about firms' occupying space but this may be indulged as more a bow to tradition than a fundamental limitation. They fail, however, to analyze the effects of land use intensity on transport costs.

Like their predecessors, Dunn and Isard accept as given the structure of transport rates and work out optimizing models within that constraint. This constitutes a serious inadequacy, not only for the obvious reason that it is idle to economize within uneconomic constraints but for the more basic reason that the economy of land use profoundly affects the social costs of transport, which effects are in turn a prime reason for economizing on land in the first place.

The effects of land use on transport costs may be implicit in the concentric ring idea and other aspects of received location theory, in the sense that all truths are consistently related and implicit in one another. But to

lie implicit and to be held up to the light are two quite different states of being. The very writers in whose works the effects are implicit may fail to apply them when the occasion arises. For example Isard at one point (p. 193), following Dunn, shows how high rents increase intensity of land use. Yet earlier he had referred to rents as deglomerative factors, following Weber (p. 183.) And he had gone on to discuss economies of scale in urban power supply, making them pure functions of city population without reference to intensity.

In discussing the social function of rent as a constraint on land use, therefore, we must do more than acknowledge received doctrine. We must show how rent serves to constrain landholders from imposing transport costs on the rest of society by preempting space that others and their traffic must traverse; and that the force of the constraint just equals the costs imposed. This in turn will call for some analysis of transport costs and the definition of an economic rate structure, an important by-product of the analysis which should be of more general interest beyond the confines of the present discussion.

C. Rent as a Quantitative Constraint on Extension in Space

The economic problem of land use is not entirely solved by establishing a qualitative "bumping order" (if I may borrow an expressive phrase from the Air Transport Command.) Land uses do not occupy seats of predetermined size. There is also the quantitative question: "how much?" Expansion by one space-user not only bumps others away, it so to speak stretches the entire transport fabric, or more accurately forces society to stretch it, and not without cost.

The positive expansive force against which the rental constraint works is the marginal net revenue imputing to land as a firm expands. While this may seem obvious, and entirely consistent with the body of marginal analysis and production economics, it is a concept never explicitly developed in the literature, at least as applied to land. Besides that it is, as we will shortly see, an analytical tool whose implications are widely flouted.

Let us begin simply by assuming constant returns to scale. This lets us consider the variation of marginal net revenue with changes in intensity, and leads directly to some interesting conclusions about the effect of rent on intensity.

In Figure 1 we signalize the assumption of constant costs by plotting on the abscissa not land alone, but the ratio of land to complementary inputs. The two solid curves

represent per acre figures: Average Gross Revenue per acre (AGR); and Average Complementary Costs per acre (ACC). The ACC curve is a rectangular hyperbola determined by the definition of the abscissa of which it is the reciprocal. AGR behaves just as any conventional average product curve, showing the result of varying proportions on output.

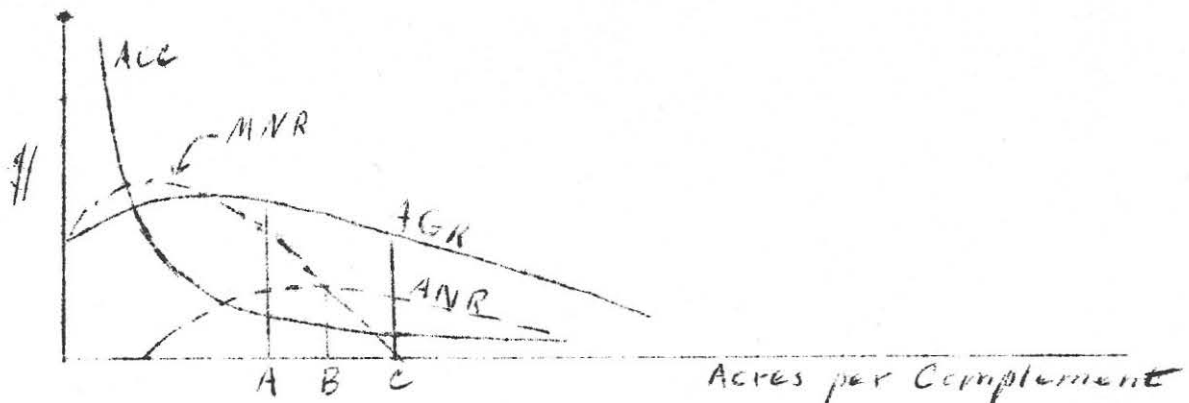


Figure 1: Costs, revenues, and derived average and marginal net products with assumed constant costs.

The difference of AGR and ACC is Average Net Revenue (ANR), which of course peaks to the right of AGR.

The most interesting curve is Marginal Net Revenue (MNR), and the most interesting thing about it is the contrast it draws between the marginal value of land to two firms, one of which is a little too intensive (position "A"), and the other of which is a little too extensive (position "C"). The average value of land is the same to the two firms, but the marginal value is much higher to the firm that is more intensive.

The curves of Figure 1 do not exaggerate how quickly marginal net revenue falls with a slight decline of average net revenue. Table 1 is a numerical example of such a relationship which I trust may make us less tolerant of the normative use of averages and of slight deviations from the maximum average net revenue.

Table 1: Relations of average and marginal revenues with declining intensity of land use.

Land (acres)	AGR	GR	MGR* MNR	CC	ACC	ANR
	(1)	(2)	(3)	(4)	(5)	(6)
1	10	10	10	50	50	--
2	11	22	12		25	--
3	12	36	14		17	--
4	13	52	16		12½	0.5
5	12	60	8		10	2.0
6	11	66	6		8.3	2.7
7	10	70	4		7.1	2.9
8	9	72	2		6.2	2.8
9	8	72	0		5.5	2.5
10	7	70	-2		5.0	2.0

* MGR is here identical with MNR. It is given as the increase of MGR from the previous acreage to the one by which listed.

Some land economists have tended to downgrade intensity as an index to the value of land, pointing out that less intensive uses may yield equal or higher net revenue per acre, or rents. But these are averages per acre, not marginal revenues. Of two uses yielding the same average net revenue per acre, the more intensive should be able in a perfect market to acquire land from the less. Thus rent-paying capacity is definitely a function of intensity; intensity is a necessary (although not sufficient) condition of rent-paying capacity; and the rental constraint forces intensification on those who must meet it.

The observation of extensive land uses persisting in central places on valuable sites has seemed to call for rationalizations, which have tended to obscure this necessary strict relationship between intensity and rent-paying capacity. However, the economist's job is not just to rationalize what he observes but also to consider the possibility that markets may not be working perfectly, and the latter explanation seems to be required to explain the extensive use of valuable land.

Now let us drop the simplifying assumption of constant returns to scale. The analysis remains quite parallel and the results analogous. This is because of the imperfect divisibility of many inputs complementary to land, which indivisibility is the basic cause of scale economies.

(Note to reader: turn to p. 8 of "Ground Rent and the Allocation of Land Among Firms", which is the second fragment I sent you, for the material to be presented here.)

Rent is more than a constraint on "extensivity" abstracted from scale. In the process it assumes a peculiarly important role as an absolute limit on scale because it is a unit cost that does not decrease with scale. This is most obvious in the short run -- as one expands his landholding he presses on his neighbors and encounters increasing marginal costs as each marginal strip of land nearer the neighbor's house or factory is dearer to him than the one outside it. It is less true in the long run, the very long run, that is, when entirely new lots are platted out and may be made larger or smaller. But even in this long run transport costs increase with distance and, as will be discussed in more detail presently, there is a slight increase in the unit cost imposed on society as landholdings are expanded.

Another reason why rent serves as a constraint on scale is because the marginal complementary costs required to integrate fringe lands with a firm's operations include rising internal transportation costs. The essence of a firm's individuality is its integral organic nature centered on some nucleus, which is a location. Land added to a firm is marginal not just in quantity but also in location relative to the nucleus with which it is to be integrated.

One may object to this that in adding more of other inputs, say labor, there is an analogous increasing cost of control and communication over lengthening lines of authority. But the analogy is imperfect. If we could conceive of additional land's being added all in one place there would be additional costs of administering it which are properly analogous to costs of administering more labor added in one place. The additional transport cost is on top of this pure administrative cost. If it be objected that additional labor is also scattered in space, the answer is that this is a function of adding more land. If more labor were added to the same land there would be no additional scatter.

In addition, administrative channels are not just costs. Man is, after all, a social animal whose work is made more pleasant and effective, up to some point, by association. The knowledge and skill of some is shared by others. But land is inert, and relatively uniform, so that internal transportation costs are simply costs without compensations other than the direct ones.

The combination of diminishing marginal net revenue to land as a firm expands, running up against increasing rental constraints as the marginal units of land become dearer to others, forms a potent limitation on economies of scale.

Yet a third way in which rent serves to constrain scale of firms is by penalizing the lavish use of land-time that characterizes large-scale operations. Large scale of capital inputs is associated, as a rule, with high durability, and the economy depends on spreading initial costs over a long period of time. Annual rent, an inexorably constant function of time, is a serious brake on all such grand conceptions. Of this more later.

D. Relation of the Rental Constraint to Transportation Costs

It is widely accepted that rent constrains individuals from excessive preemption of limited natural gifts like beach sites or alluvial soils. It is less obvious but equally or more important that rent serves to constrain economy of space which others must traverse, and that the force of the rental constraint tends to equal the traversal costs which are privately felt.

This is a most important principle for the economical layout of transport-utility networks, and the pricing of their services. While it may appear elementary it seems never to have been formally expounded--not at least to my knowledge. And its policy implications are widely ignored, not only in practise but in scholarly treatises whose authors were presumably freed from the pressures of compromising with irrational institutions and traditions. It is the more important, therefore, to spell it out explicitly and carefully.

Let us suppose a row of five lots, equal in all qualities save location, running uphill from a common source of free water, S. A Water District serves them from a common pipeline, delivering to the uphill corner of each lot. Pipe capacity fits demand all along the line, declining after each outlet gate.

Water is free at the source, but not at the outlets. Service at each outlet is priced to cover marginal costs and each lot pays an additional flat charge to cover the rest of the costs (fixed pipeline costs being of course decreasing with capacity.) These charges between them cover the costs of bringing service to each lot. The exact formula for allocating common costs among lots is developed later, but for the present we may note that the sum of charges increases slightly more than in proportion to distance because of the small capacity and high unit costs of the higher sections of the pipe.

The capacity needed for each lot is represented by a line running from its service outlet to the water source. The lots are designated in ascending order A, B, C, D, and N. N is the marginal lot whereon the benefits from bringing water are just exhausted by the costs. As our curtain rises lot N is empty.

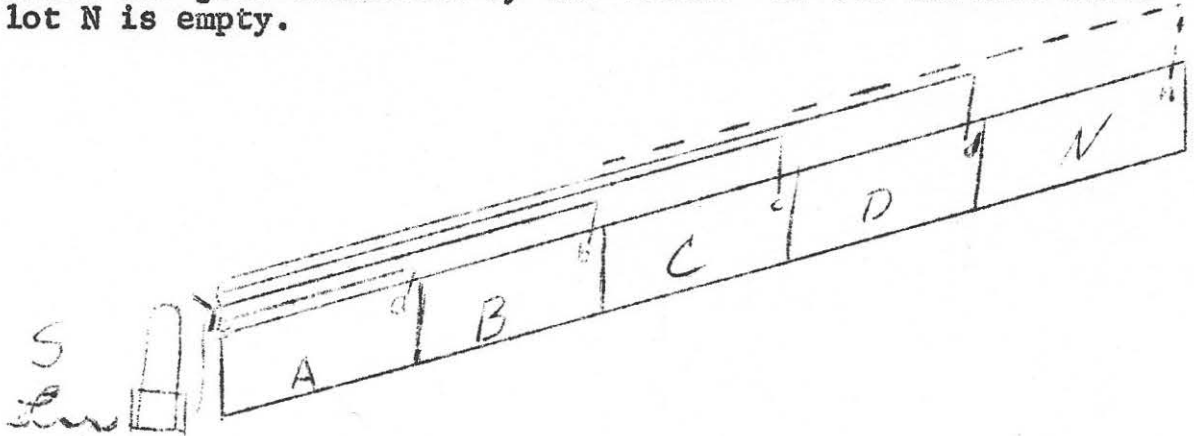


Figure 3: Schematic Diagram of Water Service to Hillside Lots

The first actor to speak is owner A, who buys lot B from owner B. B must now find a new site. We might have B crowd C, C crowd D, and D move on out to lot N, but this is needlessly complicated. The same result may be reached more neatly by postulating that B move directly to lot N without disturbing C and D. C and D remaining unaffected, the entire social cost may be summarized in the losses suffered by B.

B will require of A a payment for lot B adequate to cover these losses. And so the price of lot B serves as an economic constraint on the spatial extension of A. A extends his occupancy into lot B only if the marginal net revenue to him exceeds the costs he imposes on society, which are summed up in the costs imposed on B at his new marginal location, lot N.

The reasoning applies to as small a slice of lot B as one wishes, so that rent may be regarded as a constraint on the marginal extension of landholdings which compels recognition of the transport costs imposed on society by individual occupancy of land.

Readers prone to sympathize with allegations that individual costs represent social costs under perfect pricing may need little more detail to rest content that B's price for his lot measures the sum of costs imposed on others by A's extension in space. Others will quite legitimately demand reinforcement by more specific identification of private costs, and their equation to social costs. Suppose, they may ask, we have decreasing costs?

Or inelastic demand for water? Or heterogeneous terrain? And combinations of these? There are several specifics yet to discuss. Such specification also forms a necessary background to our later consideration of the divergence of private from social transport costs, and its effects.

What losses are imposed on B by moving to lot N, and how do they relate to the sum of costs imposed on society by A's extension in space? Let us begin with short run variable costs, exemplified by power inputs for pumping. For initial simplicity assume the costs are constant functions of volume and distance.

When B moves to lot N he must assume additional costs of pumping water past lots C, D, and N. These costs cut into the net gains he makes on such water as he still pumps at the higher water rates. It also obliterates all the gains he was making on the amount of water that becomes submarginal at the higher water rates, but let us defer that question for a moment by assuming perfectly inelastic demand for water.

Water previously delivered at B's outlet gate, b, must now be pumped three more lengths, past C, D, and N. The additional capacity required is shown as the dash line of Figure 3, which we will call "subline N". The cost imposed on B is the cost of pumping over subline N.

To assure ourselves that this represents social costs let us conceive of the result in a way that involves all the owners. Suppose B, C, and D had remained in order but had each moved uphill one lot. The result would be the same, that is one more subline of water would have to be pumped past lots C, D, and N.

Finally let us note that the increased costs equal the costs of traversing lot B: that is, pumping one unit of water past three lots is equivalent to pumping three units past one lot (B). The result is the same as though A were in possession of a land growth hormone which caused lot A to grow longitudinally, pushing the others before it away from the water. The additional costs imposed on society are the costs of traversing the new distance thus created.

So far, then, the costs imposed on society may be summed up in the costs imposed on B; these costs equal the costs of traversing lot B by all higher water users; and rent will serve as an economical constraint on preemption of land.

Now let us consecutively drop the simplifying assumptions of constant costs, inelastic demand, and homogeneous terrain, making our conclusion as general as we can.

The cross-section of a pipe grows r times faster than its circumference (where r is the radius) so that unit costs of pipe capacity over given distances typically decrease. If we are to deal with the fixed as well as the variable costs of transport we must certainly take cognizance of this. Even the variable costs will be affected, or should be, since the most economical sizing of pipe will be that which tends to equate short run with long run marginal costs.

Decreasing costs do not alter our conclusion that the cost of traversing lot B equals the cost of extending service from outlet b to outlet n along subline N. Let us conceive of the entire pipeline as composed of "sublines" labelled for the lots they serve, and each subline in turn composed of sections labelled for the lots they traverse. Lot C, for example, requires the capacity of subline C composed of sections A, B, and C which traverse the lots of the same names.

We have seen that B, upon moving to lot N, must pump water three additional lengths, from b to n . Under the present assumption of decreasing costs, however, the three sections of subline N are not of equal cost. The N-section is the center and only ring of the pipeline traversing N; the D-section is the second ring of the common pipe traversing lot D; and the C-section is the third ring.

But the common pipe traversing lot B consists also of a first, second and third ring, serving respectively lots C, D, and N. (Service to lot B at outlet b , recall, was discontinued with the purchase of lot B by A.) So again the traversal costs for all service beyond lot B equal the cost of extending service to lot N.

It also remains true that we may regard the addition of subline N as equivalent to an inflation of lot A which pushes all the others one length uphill. For this would result in the pipe's becoming one ring thicker at every point right of b , which is exactly the result of adding subline N.

Now let us proceed to the harder task of dropping the assumption of fixed demand. To ease the way let us first temporarily regress to the assumption of constant costs.

Water will certainly be subject to diminishing returns on each lot. Demand curves for water at each outlet will therefore slope negatively. So when B relocates on lot N he will not take as much water as before, since prices are higher at turnout n than at b . Subline N will be smaller than previously assumed, and pumping costs correspondingly less.

At first blush this seems to destroy the equality of traversal and extension costs. Traversal costs are now greater than extension costs because lots C and D take more water than lot N. But B's losses are also now greater than his costs on water, and these extra losses make up the difference as will now be shown.

B's losses are now greater than his explicit outlays on subline N and the costs of pumping through it. B also loses on the water he used to make money from on lot B but can no longer buy at the higher water rates of outlet n. These implicit losses equal the extra traversal costs past lot B.

Figure 4 shows the long run marginal costs of delivering water to the several turnouts under our assumption of constant costs. The demand schedule applies alike to each lot, under our assumption of homogeneous lots. Each cell in the Figure represents the cost of one section of one subline. Each cell-row, from the ordinate to the demand curve, represents the cost of traversing each lot with its own supply. Row A, for example, represents the cost of the five units taken by A carried past lot A to outlet a.

Each cell-row plus the rows above it and under the demand curve equals (although without specifically representing) the total traversal cost of the corresponding lot. The cost of traversing lot A, for example, is the total area under the demand curve. (Footnote: ignoring the half-cell triangles, which become negligibly small as the units become small.) Past lot A must go five units for lot A, four for B (before B moves to lot N), three for C, two for D, and one for N (or none if we assume N is not yet occupied.) Each column of cells represents the cost of carrying one unit of water to the lot represented by the top cell.

The costs of traversing lot B, on which our present example focusses, are first equal to cell-rows B, C, and D. (They are specifically represented by cell B1 taken 3 times, B2 x 3, B3 x 2, and B4 x 1, a distinction which takes on significance when we reintroduce decreasing costs.) This is a total of 9 cells. After B moves to lot N, outlet b is closed and replaced by n, which takes only one of the four water-units b was taking, so that traversal costs fall to 6 cells, equal to rows C, D, and N (B1 x 3, B2 x 2, and B3 x 1.)

The extra cost of extending service to B at lot N is the 3 cells C1, D1, and N1, representing the cost of carrying one water-unit past 3 lots on subline N. This makes it appear at first as though B's losses are less than the traversal costs, but B's losses are greater than these 3 cells. For at lot B he gained two cells worth of rent from the 2d water unit he took there, and one cell's-worth from the 3d water-unit. These 3 cells of lost rent (C2, D2, and C3) bring his losses up to 6 cells, equal to the costs of traversing lot B.

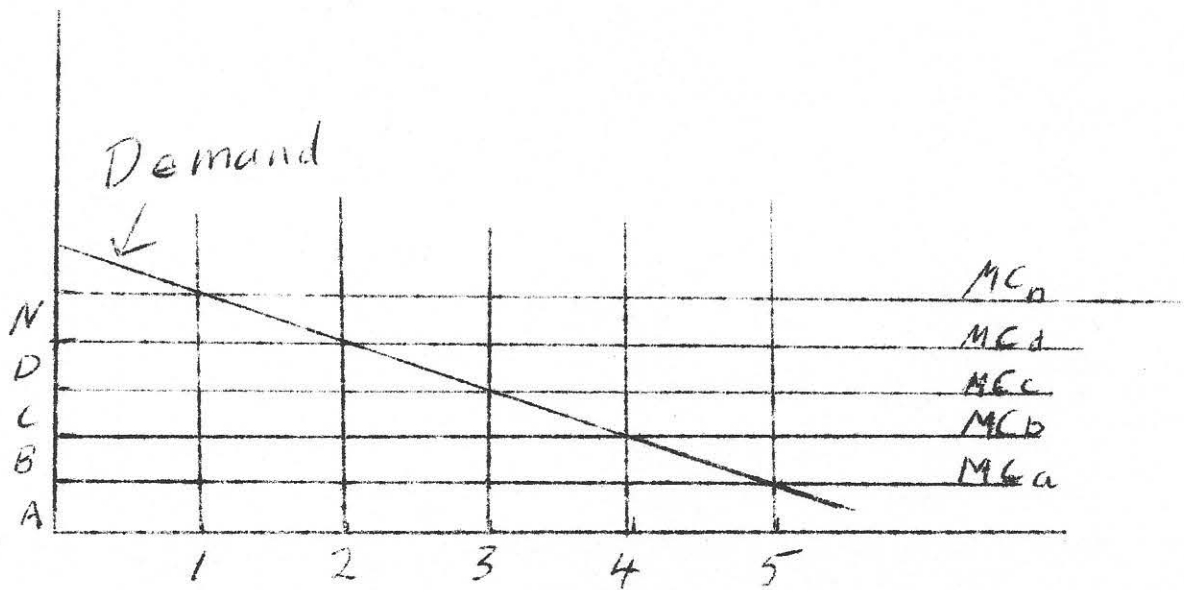


Fig. 4

Now let us again drop the assumption of constant costs. It can be shown that traversal costs still equal the sum of B's losses. This requires an extension of the same reasoning in three dimensions and becomes a little more complex. (Note to reader: this proof will be inserted later.)

Finally let us drop the assumption of homogeneous land. Suppose lot B is very rough land of low carrying capacity and high traversal costs. When A bumps B out to lot N the losses imposed on B are clearly much less than traversal costs, since B had little to lose and traversal costs are high for natural reasons. We cannot therefore accuse A of imposing these traversal costs on society, but only the much smaller costs of traversing the space B would occupy if instead of moving to lot N he had crowded C, who crowded D, who moved to lot N.

May we now be certain that the losses of B represent those of the whole society? (Note to reader: this section is to be expanded.)

Summarizing, then, the losses imposed on society by one landholder's extension in space are generally accurately summarized in the losses suffered by one individual who is assumed to be displaced to the end of the system. Such marginal individuals will bid up intramarginal rents to levels where they serve as economic constraints on extensivity of land use. This conclusion is no better than the assumption that transportation services are optimally priced.

E. Rent as a Constraint on National Territorial Expansion

We have been quite technical, and we will be again. Let us pause for a moment to consider some of the broader implications of this work, which must ultimately justify the technical effort.

The aggregate of cities and rural regions make the nation. The rental forces that constrain individuals to intensify their land uses within local economic units serve in the aggregate as an important pacifistic force. The nation that tends its own lands does not need to covet its neighbors lands.

There was perhaps a time in American history when the expansive bias of our institutions might be justified by the presumed needs of "manifest destiny" calling us to the Pacific, to preempt a continent from rival empire builders. Today our problem is rather one of adapting our institutions to maintain a viable domestic economy within fixed territorial boundaries, free from the compulsive drive to expand which finds its present outlet in the senseless disintegration of our cities.

The ultimate goal of our analysis of rent, therefore, is not to build toy models but to build a foundation for policy decisions relating to transport rates and to rent that are appropriate to the age when we finally must face the fact that the world is round, and finite.

RENT AS A CONSTRAINT ON EXTENSION IN TIME

We have seen how rent serves to check unlimited extension in space, that is to allocate land among adjoining users. Rent also serves to allocate land among successive uses, that is to check unlimited extensions of use in time.

Extension in space, with fixed complementary inputs, obviously makes land use less intense by spreading the fixed inputs over more land. It is a little less obvious, but equally important that one reaches a similar end by spreading fixed inputs over more land-time. One does this by letting buildings depreciate and yet survive over many years at low values unrenewed, thus encroaching on the time-margin of land use.

The primary constraint on this temporal extension is again rent, which one may view as part of the marginal cost of time. Rent puts land uses under pressure not just from all sides but from the future. Rent is not the only marginal cost of time--all costs have a time vector. But rent behaves in time as in space, that is it holds up inexorably at fixed or rising levels as one approaches the margins of decision where other costs taper off.

An important exception to this pattern should be immediately conceded. It is comprised by biological capital like timber or cattle, which appreciate with time, and in a sense by all forms of capital which are embodied in the final product and so appreciate over time. It is ironic that the function of rent as a time-constraint should have received its most extended and sophisticated treatment in forest economics, where its relative importance is, while not negligible, much less than in other fields.

But the more usual capital input occupying land depreciates and obsolesces with time and has little, no, or negative salvage value toward its senility. Without rent old buildings would almost never be demolished. On a base of zero any return is infinite. Along Park Avenue today a sound 30-story building has just fallen to the wreckers' ball to release the site for a larger modern improvement. The same building in St. Louis, or another part of Manhattan, would survive another half-century; in Aberdeen, S.D., perhaps two centuries; in Malta Bend, Mo., until it fell of its own weight, for it could always be used for storing grain, or old equipment, and ultimately for disposing of junk. There is always a use, however humble, for an old building. If the site beneath has no salvage value there is no limit to economic life but sheer physical collapse.

This function of rent is known to urban land economists, but somehow it has never found its way into the main body of production economics which has tended to remain not only spaceless but timeless. Open almost any tome on cost analysis or price or production economics and you will see the axes labelled "Input A" or "Output B" with no reference to the time unit assumed, or the method of annualizing fixed costs. It is to the credit of Boulding that he has made the effort to apply marginal analysis to time economics, but he has concluded--I believe mistakenly--that marginal analysis there breaks down. Literature on capital theory has tended to neglect both marginal analysis and the role of ground rent. I hope I am not preaching to the converted, therefore, in expanding on the role of rent as a temporal constraint.

The rental constraint on time-extension operates more specifically as follows. Let us adopt Terborgh's expressive wording and describe old and new rivals for a site as "defenders" and "challengers". The time to salvage an old site arrives when the defender's current annual income net of operating costs falls below the top challenger's anticipated annualized rent net of all costs. Note that we are biased for the defender because its capital costs are already sunk and nonsalvageable, so in the marginal comparison we deduct no charge on sunk capital, neither depreciation, obsolescence, nor interest. What's done is done and historical costs are irrelevant even if embodied in outstanding debt.

The challenger's annualized net rent is a more difficult concept. Since the challenger is typically not another firm but another land use contemplated by the same firm we have little excuse to assume this rent has been correctly determined "externally". We will have to compute it ourselves.

A new use typically entails heavy initial costs compensated by revenues tapering off over many future years until the next challenger succeeds to the site. The entire cycle of investment and liquidation is an indivisible unit that must be evaluated as a whole.

The challenger's rent must be an average of its performance over time. A simple mean will not do, however, for in addition to the quantities of costs and revenues we must consider their distribution in time. A "time-average" is necessary. This is found by annualizing all costs and revenues--for brevity let us henceforth say simply "net revenues". Annualizing a quantity of given time-position means finding the amount, call it a, which if received as a constant annual sum over the life of the investment would be of equal present value with the said quantity received once.

Net revenues in the terminal year, t, are annualized by the following standard formula:

$$a = \frac{i R_t}{(1 + i)^t - 1} \quad (1)$$

where R is net revenue, i is the relevant interest rate, and t is the terminal age of the improvement.

Net revenues in any other year, n , are annualized by compounding them forward to the terminal year, t , before applying the annualizing operations of equation (1). Thus the complete annualizing formula is:

$$a = \frac{i \sum R_n (1 + i)^{t-n}}{(1 + i)^t - 1} \quad (2)$$

It only remains to select the value for t that maximizes a , which one may do in a number of ways.

It reassures one's faith in marginal analysis to note that one way of doing so is to find the year when $R_n = a$, that is when the marginal revenue of time (R_n) equals the marginal cost of time (a). In the first years of heavy initial costs the values of R_1 , R_2 , and so on may be less than a , and ordinarily will be even less than zero as the initial costs are counted as negative revenues. This is inevitable in the nature of long-term improvements. But toward the later years any value of R_n which fell below the running time-average, a , established by preceding years, and not representing a new investment to be requited by later revenues, would lower the time-average of the whole and call for demolition and renewal.

Which is also to say that in time analysis, as in space analysis, and as in the timeless-spaceless abstract analysis on which economists have cut their teeth and on which still nourish their young, a marginal revenue function intersects the corresponding average revenue function where the latter is a maximum.

One may object to the foregoing that it implicitly assumes the second challenger will be identical with the first, and the objection has weight. If, as is often true, our best forecast augurs a higher rent for the second future stage than the first, the problem of setting the rent of the first grows a little more complex. It becomes necessary to shorten the life cycle of the first challenger -- making appropriate optimal adjustments in type and intensity of improvements -- so as to cut off its life when its current net revenue, R_n , fell below the higher future rent, a , of its challenger.

This will reduce the $\bar{a}$, the time-average rent of challenger #1. This might seem to weaken its challenge to the present defender and postpone demolition, but the opposite is true. For it is with the marginal, not the average value of time that we must make our decision, and when we constrict the time-dimension of land use and increase the intensity of improvement we push the marginal revenue above the average, just as when we constrict the space-dimensions. The optimal marginal adjustment will be therefore to accelerate demolition and renewal.

This adjustment is optimal, however, only to a point, for as this constriction elevates the marginal rent of challenger #1 it depresses its average rent, $\bar{a}$. At some point the time-average falls below that which the present use would yield over the same period and it becomes optimal to skip over challenger #1 altogether, proceeding direct to #2. In fact to skip #1 becomes optimal even before this point is reached if the skip will accelerate the inception of the reign of challenger #2 with its anticipated higher rents.

Anticipation of higher future rents, therefore, will tend to increase the constraining force of rent up to some point, but then rather abruptly to remove it almost completely when an overall evaluation of challengers #1 and #2 prescribes skipping #1.

The use of this argument by some economists has been about as unbalanced as the press conferences of the champion's manager seeking to duck his #1 challenger. Emphasis has been largely on the removal of the rental constraint by a too-easily presumed optimality of skipping challenger #1. The principle of avoiding premature commitment groans beneath the burdens heaped on it. At the hands of R. T. Ely of the "ripening costs" doctrine it served to rationalize the major speculative follies of the suburban land bubble of the 1920's.

Ely's excesses should not blind us to the real merits of the position. When a comprehensive and sober analysis of future prospects truly bids us skip challenger #1 let us bow to the force of the argument, gentle as doves. But let us also be wise as serpents and habitually skeptical of an argument that lends itself to pie-in-the-sky apologetics from the apostles of Dr. Pangloss. There are other reasons why valuable land remains unrenewed, reasons which will bear further investigation.

Rent and Intensity Through Time

The accelerated replacement constrained by rent is a form of intensification of land use, as one would expect from the operation of a land constraint. Without the constraint

the individual's motivation would be to squeeze the last drop of income from the initial inputs by spreading them over as much land-time as they would endure, thus minimizing the time-average of his costs without regard to the time-average of his revenues.

The intensity that the time-constraint encourages is of a sort that is not necessarily obvious if we should observe the static ratio of land to improvement at any given point of time. Intensity over time takes the form of faster turnover of improvements, rather than heavier initial improvements. Rent as a spatial constraint, it is true, prompts heavier initial improvements, but rent as a temporal constraint, chopping off the last years of each cycle, puts a premium rather on quick recoverability of capital, on flexibility and speedy replacement. Rent penalizes the ponderous and the monumental and so has a tempering influence on initial costs. Its influence is rather toward maximizing volume of business, the joint product of capital times turnover.

This influence of rent is pervasive, affecting not only buildings but the daily use of rooms, floors, and shelf-space. Rent is no less the executioner of the creaking lathe and the stale bread than the firetrap apartment and the tired orchard. A high-rent economy is one that economizes on land-time by introducing a note of urgency into all phases of life.

Rent is not, however, entirely the enemy of quality, substance and durability. It is an optimizing force that abhors extremes. While it does not let the minimization of time-average costs dominate decisions to the extent of overlooking time-average revenues, neither does it the opposite. It rather strikes a golden mean maximizing the excess of time-average revenues over time-average costs.

In Equation (2) we submerged this relationship by combining revenues and costs in one inscrutable expression, R_n . Let us now express them separately and observe graphically a typical interplay of the time-averages of costs and revenues with increasing life of improvements (Figure 5).

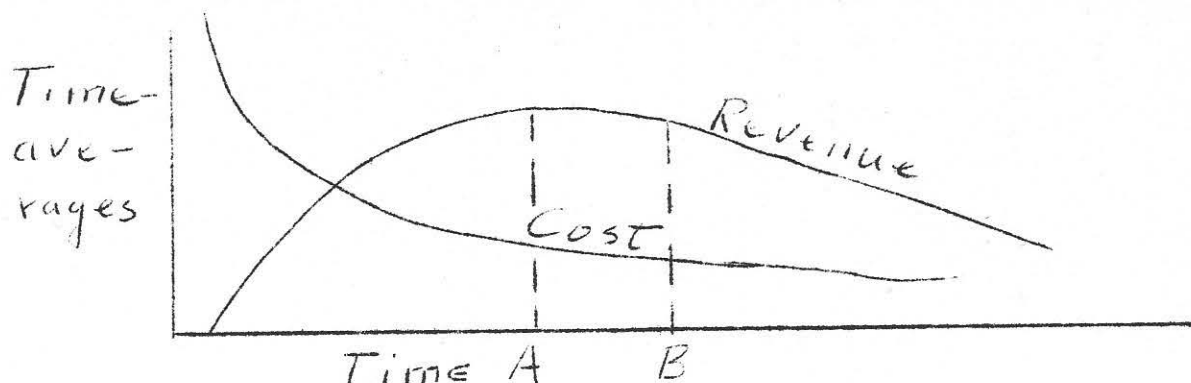


Figure 5: Time-averages of costs and revenues over building life.

Here we see the same principle as in Figure I applied to time instead of space. The rental constraint precludes indefinite rightward drift because the slight decline of time-average costs is offset by the sharper decline of time-average revenues. The rental constraint does not however drive us clear back to the maximum of time-average revenues at A, for there time-average costs are too high. It drives us rather to B, where the curves are parallel and farthest apart, and time-average rent is a maximum.

Rent as a Constraint on Economies of Scale

Rent in its temporal aspect tends, just as in its spatial aspect, to limit economies of scale. Scale economies arise largely from the imperfect divisibility of fixed capital inputs. We have seen that decreasing costs are realized by spreading these over space, and limited by the constant or increasing costs per unit of space. Decreasing costs are similarly realized by spreading fixed capital costs over time. Large capital inputs tend to require the complementation of more land-time as well as space, because size is associated with durability, not to mention long preliminary assembly, planning and construction periods.

As fixed capital inputs are spread over more land-time there are realized decreasing average time costs (Figure 5). But there are in general no decreasing land-time costs. Rent, representing the time-cost of land, flows on inexorably and is even likely to rise.

Large, fully integrated mills, factories, and state-wide water projects promise impressive economies to scale, of which it is easy to become enamored. Unfortunately many of these economies rest on the implicit presumption that heavy initial costs may be spread over ample future time. Limit that future and the mammoth becomes a white elephant.

Relations of Temporal and Spatial Constraints

Being a form of intensification, the faster turnover constrained by rent tends to save space for society. Higher rent on land keeps a larger volume of capital, averaged over the years that is, on a given site; it gives more frequent employment to construction labor and probably on balance to other labor as well; and it provides more consumer satisfactions. Thus it relieves the pressure to expand onto new lands.

The converse is also true. Availability of empty lands for expansion eases rental constraints on older lands, destroys the incentive to salvage old sites for new uses, and lets the older areas degenerate into economic deserts.

A reason some of the worst slums in the Western world are found in American cities is the same reason we have bequeathed posterity some of the world's most abused soils and heedless camping manners: ours has been a migratory culture premised on continual territorial expansion.

Not only have we had a continent to settle, we have subsidized one new form of transport after another, relieving peripheral sites of much of their natural disadvantages and spreading thin the economic rent that would otherwise have arisen on the older sites. Let me not overstate the point--there are opposing forces, and continual efforts to maintain artificial scarcities of older lands. On balance, however, our institutions and culture seem attuned to making accessible an artificial abundance of land--"artificial" in the sense that it is more than is justified by net economic gains. The result has been exploitation at the new fringes and stagnation in the older centers, twin results of inadequate rental constraints.

Macro-economic Impact of Rent and its Fluctuations

It is scarcely recalled today that macro-economic analysis, as foreshadowed in the writings of Wicksell, began as a study of the rate of turnover of an economy's real capital stock. Now economists have become so involved in the details of manipulating monetary flows that we are in danger of neglecting other influences on economic activity. One of these is the level and impact of ground rents. From the foregoing analysis it follows that these must profoundly influence the time-rate of capital turnover and thereby the aggregate of economic activity.

If ground rents were a static factor we might lump them with natural forces as "given". But in fact ground rents are not fixed. Viscous they may be, but static, no. The ups and down of land values over a long cycle of about 30 years are matched by few other commodity prices, and certainly by none of comparable importance. It is hard to imagine that these giant swings in the price of land-time have no impact on the time-rate of turnover of capital applied to land, and thereby on aggregate economic activity.

Now "put the case, Mr. Pip", that the nation's capital stock were spread over so much land that land had no rent. Then the stock would turn over very slowly. In a typical boom cycle population and capital do move out from established centers, aided by new forms of transportation, and spread themselves thin. They move out at first and for a long time to the accompaniment of high and rising land values. High land values in the older centers help speed the recovery of capital from improvements on older sites to help finance the new expansion. But the process ultimately brings so much

land into the market as not only to stop the rise of land prices but reverse it and, in serious depressions, to drain most of the value from large areas over which new capital is spread. This process leaves so much of the nation's capital stock spread so thin over so much land of so little unit value as to freeze the capital nearly solid, irrecoverable.

Could this outcome fail to check aggregate economic activity? I think not. The full pursuit of this question lies outside our present scope, but it does suggest that the implications are far-reaching indeed of rent as a constraint on land-time.