R74 "Completed" MSS

III. Ground rent as incentive & constraint: the allocative fn.

A. Rent as incentive vs. rent as a surplus

Ground Rent as an aggregate distributive share is a surplus, we have maintained, distinguished from other dist. shares in being unnecessary to evoke the aggr. supply of land. It & the inputs to which it attaches.

Factor payments have 2 fns however. Besides calling forth the aggreg. supply they also ration it, or allow. it among competing uses. Rent serves the 2d of these fns quite as much as do other shares. The incentive to put land to its best use is to earn the highest rent, and — what is another aspect of same thing — the constraint against using land in inferior ways, or using too much land, is the opp. cost repd by the max. attainable rent.

B. Accepted doctrine & some of its limitations

"Rent," wrote E&W, "acts as the 'sorter' & 'arranger' of this pattern (of land use)" (p. 139) It preempts the choicest sites for the uses that need them most & orders land uses in a hierarchy ~~from the most to the least~~ according to their rent-paying capacity.

The body of doctrine called location thy as devd. by Thunen, Weber, Losch, Hoover, Bunn, and Isard, and others elaborates on this principle at length so that the allocative fn of

of rent may be regarded not only as received doctrine but as rather highly developed doctrine.

For all the attn. the topic has received, however, some quite important aspects have been badly neglected. Major emphasis has been given to fn. of rent in ~~ordering~~ ranking land uses in ~~a ranking~~ order of rent-paying capacity. Less attn. has been given to quantitative fn. of rent in determining how much land ~~each~~ each firm & use can ecly occupy; and still less attn. to ~~relationship of~~ the social rationale for the spatial constraint in terms of xptn savings to members of the society who must traverse the space occupied. I.e., location thy analyses influence of xptn costs on (own)

The major authors have in fact universally disbarred themselves from fully considering the last qu. by [setting xptn costs beyond the scope of their analyses. To a man adopting the assumption that pvt. xptn costs rep. the social costs. This is not to say location ecsts believe the assumption is true, ~~but~~ It is only a simplifying assn such as all reasonable readers will ~~indulge in~~ accept tentatively. But the fact that no location ecst has had occasion to relax the assn. ~~it~~ betrays their neglect of the fn. of rent as a ~~space~~ constraint on extension in space. For to evaluate that fn one wd. have to show just what the full social costs of xptn are, and how they are Ad by Ad size of lots.

land use; but it does not fully analyze the converse, the influence of land use on xptn cost.

It does tell us that individuals ~~tend to locate where they minimize xptn costs, & those~~ tend to preempt w. greater demands on xptn ~~resort to~~ central sites & so min. aggreg. xptn. costs, & this is important info. But if all land users, preserving their ~~scenic~~ ordinal ranking, were to double their space occupancy, they wd. double xptn costs also vary w. the overall intensity of land use. & xptn mileages & also probly social costs per mile. Clearly an imputed fac. of rent is to constrain such expansion to the end of min'g xptn costs. Clearly, too, this is one of today's most int'g qns., in an era of rapidly ↓g per cap. space use both in farm & city areas. It is a qn. on which location thy, qua us little explicit guidance, and few specific analytical tools.

E.g. Now suppose it be true, (as in fact I believe it is), that ~~social~~ pvt. xptn costs at the fringes of cities ~~tend~~ for all commodities — that is includes utilities — are less than social costs. This wd. have only minor effects on the (com) This wd. tend to relax rental constraints in the central city below an ec. level and reduce intensity there. This in turn wd. disperse popn. ~~and~~ wider, imposing ~~ad~~ costs on society. Thus subsidy to xptn wd. cause pvt adaptations ~~to~~ through reduced central rents & ~~and~~ peripheral ones, imposing heavy unec. burdens on society, not simply in s.r. pvt. adaptation to given fixed facilities but ~~in~~ in l.r. worsening demand for new ones.

If this be true or not calls for analysis of social costs of xptn as related to size & intensity of landholdings at different locations. But ~~in the absence~~ are we sure that rent is an optimal constraint on quantitative extension of land occupancy, even in the absence of xpt subsidy? Do we know enough about xpt costs to know whether xpt is subsidized or not? ~~Do~~ Wd. we know ~~what~~ an ec. pattern of xptn charges if we saw one? There are still unanswered qns.

~~The extreme in neglect of~~

Probly no location theorist has neglected ~~quantitative~~ the space requirements of land uses so ~~completely~~ as did Weber & those who follow in his tradition. Weber assumed industries that were dimensionless. ~~They were~~ His sites are merely points. ~~How~~ It shd. be fairly obvious that industries are separated by space largely bec. industries & others occupy intervening space. In Weber's scheme this difficulty is overcome by arbitrarily dividing industry into those that do & do not occupy space

ordinal ranking of landuses & so does not appear worthy of great attn. in the framework of most location thy.

the former being "agricultural." Curiously the tradition has persisted so that even today "industrial" & "agric." location they are treated as 2 separate topics.

~~The assumption~~ that ~~industry~~ urban industries have negligible space requirement is equivalent to assuming intra-urban xpts is negligible ~~for~~ to inter-urban, ~~something~~ a point every airline passenger can refute. It is not to assume city planning is a useless study, and there are no urban distribution costs.

In fact, while urban industries do occupy less space than agr., it is much more valuable space, & space which ~~stands~~ lies in the way of much traffic of ~~many~~ more people and utilities & commodities in the city's circulatory system. ~~and whose economy~~ Moving from country to city the importance of xpts on space grows larger as factor space requirements grow less, and probably faster because of the higher rate of turnover of capital in urban the surrounding urban sites. The Weber tradition is ∴ not only an oversimplification, it is absolutely ~~opposite~~ misleading & probably opposite from a correct emphasis.

Weber's lack of appreciation for rent's function in constraining overuse of space was sufficiently profound to cause him to identify rent as a "deglomerating" factor, a ~~factor~~ social cost of congestion tends to drive people from crowded cities. It is true that high rents drive ~~those~~ extensive uses from central cities, but of course they do

so to reserve the land for intensive uses. Scarcity of central land is basically the force driving people from central places. Rent, viewed as a constraint on the landholder, has the opposite effect by forcing him to ~~ecge~~ cling closely on the land

The "ag." tradition in location thy, stemming from Thunen, ~~is far more~~ does ~~give abbn. to~~ recognize the spatial extension of land uses, resulting in concentric rings of land uses around market centers. ~~Thunen's analysis is limited by his assumption of fixed intensity. Within each ring, that is, output per ha. is fixed, regardless of changes in Ag xptn charges toward the outer boundary. Intensity may be changed only by changing crops.~~

Emphasis is entirely on the ordinal ranking of uses, however, not on intensity of use. Thunen in fact assumed constant intensity ~~but the more serious~~ within each ring. ~~Thus the effect of xptn costs on land use are only partly described by rent. The neglect~~ is of the effect of intensity on xptn costs. ~~xptn~~ rates are simple functions of distance (?), w/o consideration ~~to~~ of scale ecs from ~~economies~~ heavier use of central roadbeds. The relation of the rental constraint to economy of xptn. is not developed, altho it is implicit in the concentric ring idea.

stopped — check later

Lösch elaborates on both Thunen & Weber, but doesn't really advance far beyond ~~their~~ the limitations imposed by their assumptions. Like Thunen his emphasis is strictly ~~on the~~ ordinal ranking land uses in an ordinal hierarchy, in which intensities of use are determined by the crop. He does not ~~discuss effect of intensity on xptn costs~~. As to Lösch's work on indl location he ~~follows~~ follows Weber in the assumption of no dimensions.

This might be viewed sympathetically as merely a crudeness. Changes in intensity do still occur between rings, which might be made very small. But it is symptomatic of a lack of concern w. effect of spatial extension on xptn acts.

Dean & I stand ~~have~~ score a major advance over the German ~~schools~~ writers by introducing continuous variability of intensity in their analyses. They ~~continue to~~ perpetuate the idea that there is something peculiarly "agr" about land use's occupying space but this may be more a salute to tradition than a limit in their analysis.

They do not, however, take the important step of incorp's in their analysis the effect of land use on social xpts costs. Like their predecessors they accept the given structure of xpts rates & work out optimizing models within that constraint. This is a serious inadequacy not only for the obvious reason that it is idle to economize within uneconomic constraints, but also because the economy of land has profound effects on the social costs of xpts which in turn ~~are~~ a ~~part~~ prime reason for economizing on land in the first place.

~~Much that I will have to say on this subject~~ over ~~some unpub~~

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

just
Possibly these positions can all be reconciled. But the changes of pace do leave an
breathless; And one deficiency at least is certain consistent. Nowhere does Isard
indicate appreciation of the effects of intensity on xpts & distn. arts, but on p. 184ff.,
he discusses ers of scale in munic. pwr supply, he consistently makes them a fn
of city size w/o ref. to intensity.

Much of what this paper will have to contribute to the subject may be implicit
in what the location received location thy., in the sense that all
related truths are consistently related and so are implicit in one another.
The work of Isard, particularly seems to hold the germs of the maximum we have discussed.
But to lie implicit and to be held up to the light of day are two
quite different states of being. In the latter position a truth has
much better chances for being converted into constructive policy decision
of pvt. & public policy.

Furthermore even the work of Isard, which is much the most
impressive & advanced of the location theorists if this paper's contributions
State. & contradictions, one or the other side of which is bound to contradict
the conclusions of this paper. I find particularly rewarding over a wide
spectrum of viewpts & assumptions that leave one perplexed. On p. 193
ff. he shows, how Dunn, his central rents cause substn of other inputs for land & ↓
intensity, a pt. which I must applaud. Yet on p. 183 he refused to his central rents as diseconomies,
following Weber. And on p. 202 he again appears again to have dropped
the substitutability of land for other inputs by excluding rent from cost,
cost curves — seemingly by cost curves — and independent of location and
etc. i.e. by foreclosing the possibility of a firm's adding land.

c. Rent as a quantitative constraint on extension in space

Qualitative not enough. / Ex. problem of land use is not entirely solved (Conkin)
How much? How much per complement, or how intensive.

Skip for 1st draft

Diving mgnl returns, vs. ~~gen~~ const. or Δg gain foregone to others
arbitrate boundaries, = ~~mgnl~~ w. neighbor
cost of traversal

~~To~~ s.r. might seem no issue bcs fixed lot sizes, but even then is some gn. of intensity of use, which is heart of gn. anyway. But fixed improvements, too, so is largely a l.r. gn. (But we will see one fn of rent is to determine when s.r. becomes l.r., i.e. when to renew.)

~~Is a mental block to handle in conceiving + thus applying mgnl anal to land.~~

largely
Is a l.r. constraint. ~~But so is location.~~ ~~But~~ Is a mental block to more than a block,
overcome, as every teacher knows, applying mgnl concept to l.r. ~~Probly~~
an extra step, for must annualize costs & revs., which is complex. Probly
explains neglect. All the more reason we shd. develop it.
For analysis is 2 steps behind need. Rent as constraint in individ
land use is one, ~~Two + that affects~~ as in the "l.r."
we recombine land & pvt. improvements. But is a still longer
run, whose ec. analysis is even more in need of devmt. when we
recombine land w. public improvements, & intensity of
individ. use determines demand for ~~Layout~~ extension & capacity of
xpt-ut. nets.

Scale, intensity, & rent; or the concept & behavior of mgnl rent.

The ~~positive~~ expansive force vs. which the rent constraint works is mgnl
rent. or mnr. While this may seem obvious, it is a concept never yet explicitly developed
in the lit.: ∴ (but check Marshall's mnp; & Joan Robinson's schedule);
and one whose implications are ~~not~~ often flouted.

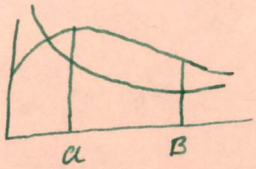
Graphs, develop schedule of mnr. Develop graphs or tables in order:

1. Fixed complements. add land. Use graph & table on next 2 pp.
2. Abstract from scale w. abscissa of "land-per-complement".
3. Comprehend all scale gns w. acc idea.

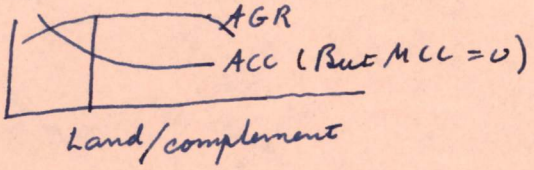
by establishing a qualitative pumping order (if I may borrow ~~an expensive~~ a phrase from ~~military logic~~ the Air Transport Command). Land uses do not occupy seats of ~~pods~~ preordained dimensions. There is also the quantitative qn: "how much?" ~~Preemption~~ Occupancy of space by one ~~occupant~~ possessor. ~~imposes~~ ~~costs~~ not only preempts it from some others, but imposes transaal costs on many others. It is the office of rent to see that these costs do not exceed the occupants' benefits.

2. Note that constraint is on "extensity" ~~as much as~~ more than on extension by individ. firm.
~~If~~ Preference for more intensive of 2 uses w. same rent. A point missed by E & W, & probly others.

Abstract from scale & show this applies to uses for plat of given size, or any size.



Same rent, but A has higher i.q.



The less intensive use may be altered to the more intensive, i.e., moving along ~~path~~ ~~of~~ path of dim. inp of land required by simple logic of ~~calculus~~. ~~mgnl~~ analysis.

~~So e.g. of~~.
Why then do uses of ~~very~~ low intensity persist on valuable land?
~~Some~~ Ecs.' job is more than to rationalize status quo.
Must consider possibility mkt not working right ---
barriers to free play of ec. forces indicated.

3. Object to unrealism of abstracting from scale?
Add scale, treatment analogous, results parallel. Ecs of indivisibility of many complements (not to be confused w. discontinuity, finite.)
Rent not just restraint on "extensity", but abstracted from scale, ~~on absolute size~~ in the process plays peculiarly important role as limit on absolute scale of opns. for several reasons.

Δg scale usually involves Δg ratio of land to other inputs, ow'g to lesser divisibility of others. Hence mgnl pr'ce of land assumes special role as limit to ecs. of scale. Greater divisibility of land is another way of say'g lesser decline of mc of land as buy more. Not always true — e.g. r-t. of way for rural roads. But in gnrl as one expands landholding he presses hardest on neighbors & meets not

declining but rising mc of acquisition, as ~~was~~ + to others rises.
Truer in s.r. than long, when new xpt-utilizing capacity laid out,
but even in l.r. land is fixed, &
~~to c~~ xpt costs Δ w. distance. Surely assume can avoid this by adding more land,
Congestion is basic cause of Δ mc, like any other input, but not entirely so. congestion at center of ps system Δs, & at outskirts Δ xpts costs
Role of rent evident by ~~no~~ effect of neglecting it. E.g. lower net gains. True of one firm, Cournot
autos, ~~no~~ & trucks, no tax on space, no constraint on size other than bottlenecks on roads. & as roads widen, cars & trucks widen too, achieving ecs of scale. If paid for space, smaller.

+ Houses.

Roads, country vs city

accounting which omits rent; even as they which omit it.
(corruption of "productivity")

Output/man always better large firms; & less intensive ops, output/unit looks better --- lower bldgs e.g. Actually a slight decline of ~~of~~ a NP means MP ≅ 0. (same not true of a P alone really?)

Also, add to other pts., Δ land never homog. re location. Surely ops have centers. Δ land is literally mgnl. i.e. in position as well as quantity.

In adjusting to mgnl concept, mind has trouble pooling all inputs & realizing "mgnl man" is not really last one hired, but refers to ~~2 Δ + etc~~ new 20 instead of 19. Most readers he. adjusted by this time. But w. land need adjust back, at least in part. Mgnl land added at fringes, Δ xpt problem inside firm. Thus the outlying lands of a firm add much less to output than those in the farmstead.

One may object to + this ~~etc~~ + that adding labor there is analogous Δ cost of control & communication, over longer lines of authority, but + the analogy is imperfect. If we cd conceive of Δ l land's being added all in one place, there wd. be Δ l costs of administering it which are properly analogous to cost of adding more labor added in one place. The Δ l xpt cost is in addition to pure adm. cost (call + them pure adm. costs)

abso of whole city, & effect on whole city shows const. or slightly ↓ag cost to individ
who expands even in l.r., while mgnl rent falls.

If it be objected that Δl labor is also scattered in space, answer is this is a fn. of adding more land. If labor added on same land, is no Δl scatter in space.

In addition, admn. channels are not just costs. Man is after all a social animal whose work is made more pleasant & effective, up to a pt, by coopn. The knowledge & skill of one is shared w. others. But land is inert, & xptn cost is dead loss.

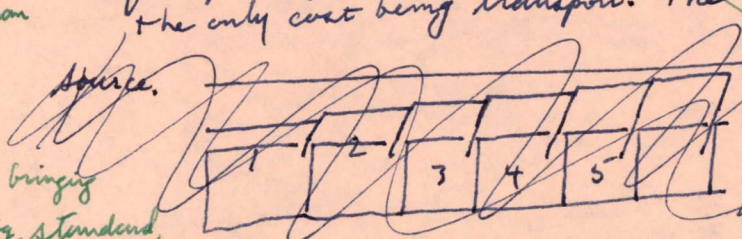
3d

another way rent constrains scale is by penalizing the lavish use of time that characterizes large-scale opns. Rent ranks with interest as a prime cost of slow building, & slow payout, & as we will see, slow renewal. Large scale plans surely call for land assembly & clearance some time before use, long developmental pd., & long life, ~~oft~~ even into pds of obsolescence. Annual rent, inexorable fn. of time, is a serious constraint on all such grand conceptions

It is obvious, and surely accepted, that rent constrains individuals to economize on limited gifts of nature, such as beach sites or alluvial soils. It is perhaps less obvious, & equally important, that rent constrains individuals to economize also on the public's contributions to l.v. on space which others must traverse; and that the force of the rental constraint tends to equal the traversal‡ costs, at least those of them which are borne privately.

This is a most important principle for the ec. layout of spt-utility nets. and bears elaboration. While it surely appears almost too elementary, for elaboration, it has never to my knowledge been formally expounded — certainly not surely so in standard works on land & location ecs. And its policy implications are universally flouted, not only in practice but in many ec. treatises. in ec. & city planning. So perhaps I may be forgiven for spelling it out here.

Let us suppose a water supply fine, equal plots in a line running easterly uphill from a common water supply, as in fig. 2. An I.D. pipe with uphill serves them all from a common pipe along their northern frontage, delivering to the uphill one corner of each plot. The pipe capacity steps down exactly fits the demand, stepping down all along the line, dropping by a step after passing each turnout outlet, for 2 reasons: Water is free at the source, the only cost being transport. The cost of transport is met entirely by prices. (I may have to assume costs other than pumping are negligible, for this e.g., to avoid l.r vs. s.r m.c. analysis which distracts from present emphasis. But that is implicit to work out.)



‡ Assuming land homog. in respects other than location. Principle applies to other lands by adding costs of bringing them to homog. standard, or deducting benefits of their being above it.

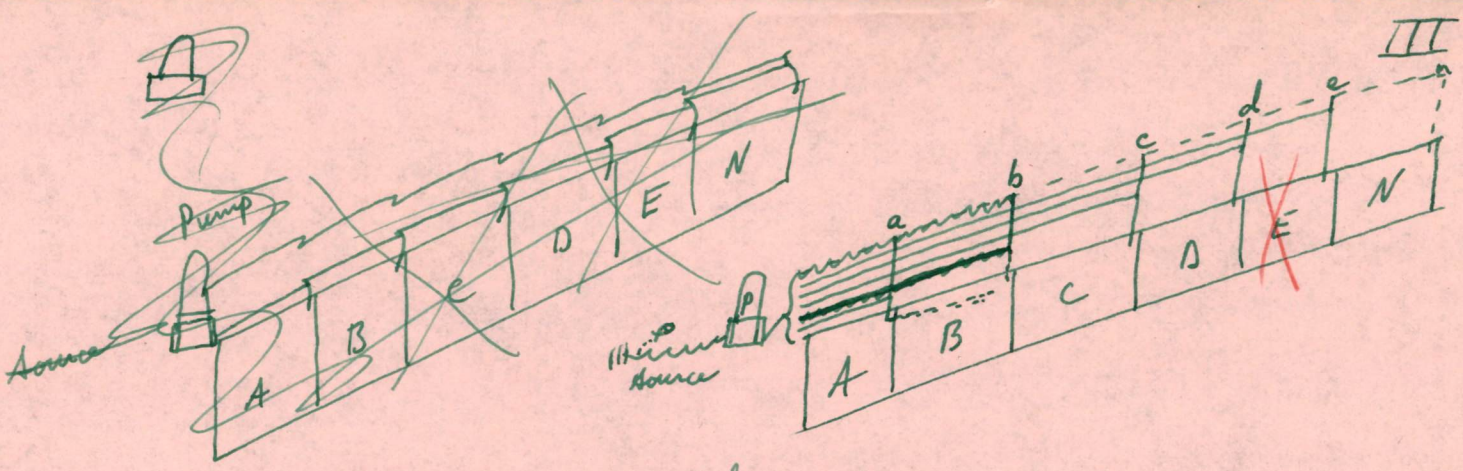


Fig. 2. Schematic diagram of

Let us suppose ~~B equal~~ a row of ~~6~~ 5 lots, equal in all respects save location, running uphill from a ~~single~~ common source of free water, S. (Fig. 2). A W.D. serves ~~them all~~ lots a to E, the 1st 5, from a common pipe line, delivering to the uphill corner of each lot. Pipe ~~line~~ capacity fits the demands all along the line, ~~becoming progressively smaller~~ declining after each outlet.

Water is free at the source, ~~By~~ but ~~all~~ transport costs are covered by charges on consumers. ~~Line capacity must be provided for~~ The charges are ~~calculated to cover costs of extension~~ increase with height and distance from the source, to reflect ~~increased~~ pumping and like capacity costs ~~that~~ ~~increase with~~ ~~of~~ that likewise increase w. ht. & distance. (Specific ~~optimal pricing~~ criteria for optimal ~~charges~~ pricing are discussed in later section.) The capacity needed for each lot is indicated by a line running from its service point to the common pump. N is the marginal lot where the total consumer benefits from water service are exhausted by the charges ~~of~~ made for it.

Now suppose owner A chooses to increase the proportion of land in his operation by buying ~~a slice of~~ lot B (~~and~~ applying the same quantity of water & other complementary inputs to the larger area, ~~By and delivering~~ ~~this~~ closing turnout b and taking delivery as before from a. The conclusions ~~are not affected by ch~~ and do not affect

~~The assumptions of simplicity of exposition~~ and may be adjusted ~~that~~ The present assumptions assume ~~that~~ that ~~this~~ ~~water~~ set to lot B above a becomes an internal problem to the firm, subsumed in lower-net benefit transactions B.

B would be "bumped" out to lot N. In order to displace B, A wd. have to ~~outbid him by~~ offering a ~~rent~~ payment greater than the losses imposed on B by the poorer location. ~~These losses are~~ ~~a 1st approximation to what losses are~~ The ~~losses~~ costs imposed on society by this expansion may be most nearly The result is to force all B & all others to the right by one length and impose all costs on all -- costs of traversing B. Is this = rent? E occupys In result, B would crowd C, C crowd D, D crowd E, and ~~so on~~ out to N, but this net result may be summed up more neatly by postulating that the resources ~~pushed off~~ lot B ~~A buy out B completely, and B~~ move directly to N. C, D, and E remain unaffected, so the entire social cost may be summarized in the losses suffered by B. B will require a payment as great as these losses to give up his lot, and to the price of the lot serves as an economic constraint on expansion. A will only expand onto B if its ~~value to him~~ mgnl revenue to him exceeds the ~~social~~ costs he imposes on society, summed up in the costs he imposes on B.

The reasoning applies to as small a slice of B as one wishes, so rent is a constraint on mgnl expansion of firms, forcing recognition of xpt costs.

Those who believe that individual costs apply measure social costs under perfect pricing may need little more detail to be content that B's price for his lot measures the sum of costs imposed on others by A's extension in space. Those familiar w. derivation of formula for sum of geometric series will also recognize (once) ~~of A's encroachment~~. Others will prefer reinforcement by more specific identification of pvt. costs. and their equation to social costs. For example, how can one be sure that B was not already incurring costs on C, D & E? Requires consideration of transmittal costs. Such specification will also be useful as basis for analysis of the divergence of pvt. & social costs and is also prerequisite to the analysis of transport costs and optim. pricing. (7, below) and may as well be presented here as there. Readers feeling this redundant may skip to a premature D forthw. th. (or make this an appendix)

~~Points to make:~~

~~Costs on B are . . .~~

~~Costs on whole society, if viewed whole as pushed out, are~~

~~Transmittal costs. Are same~~

~~In short, better to regard as A's costs on B, his terrain~~

~~not homog.~~

1. Begin w. pump costs, assume const. fns of vol. & distance
Run thru all reasoning w. const. costs. Then introduce vble ones as elaboration, & leave elaboration for after June.

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 s.r.v.c., ~~in this~~ exemplified by power inputs for pumping. For initial simplicity assume these costs are constant functions of volume and distance.

cancelling-out of intermediate terms

an ~~close~~ analogy to the [illegible] employed there.

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

~~B's Δl costs are the costs of pumping.~~

Wtr previously delivered at B's turnout b must now be pumped 3 more lengths, past C, D, & N. ~~The cost of the~~ This is the Δl cost imposed on B. Now to assume ourselves that this reps. social costs, let us ~~conceive of the result in a way that involves all wtr users.~~ ~~the costs in another way that involves all wtr users.~~

~~Suppose now that~~ same as it wd. be if owners B, C, & D had remained in order but each shifted one lot uphill: One more unit of wtr must be pumped past each of lots C, D, & N. Finally let us note that the Δd costs = the costs of traversing lot B: i.e., pumping one unit part 3 lots is equivalent to pumping 3 units past one lot (B). It ~~wd. be~~ is as though A ~~had expanded by~~ now in possession of an additional land ~~entirely new parcel~~ ~~the application of a new growth hormone~~ extender stimulant which caused ~~his~~ lot a itself to ~~extend~~ grow longitudinally, pushing the others before it, away from the water. The Δl costs imposed are the costs of traversing the new distance thus created.

Thus the costs imposed on society may be summed up in the costs imposed on B; these costs equal the sum of all costs of traversing B; and rent may be said to serve as an ec. constraint on land preemption occupancy.

Now let us consecutively drop the assumptions of inelastic demand, constant costs, ~~constant costs~~, & homogeneous terrain, making our conclusion as general as possible.

(When get to inelastic demand, begin by going back to const. costs first, then handle both together)

(Dropping ass. of const costs lets us handle fixed costs)

a. Decreasing costs

~~[illegible]~~ The x section of a pipe grows $\frac{x}{}$ times faster than its circumference (~~[illegible]~~ $\frac{d(\pi r^2)}{d(2\pi r)} = r$) so that unit costs of pipe capacity ~~[illegible]~~ over any given distance may confidently be expected to full. If we are to deal with the fixed as well as the variable costs of ~~dist~~ transport we must take cognizance of this. Indeed even the variable costs are affected, or should be, since the most economical sizing is one which tends to equate

s.r. & l.r. mc.

Decreasing costs do not alter the equality of returns the ~~financial costs and~~ ~~[illegible]~~ costs of transiting B and extending service from a terminus to n. Let us conceive of the pipeline as composed of "sublines" labelled for the lots they serve; and the sublines in turn composed of "lengths" labelled for the lots they traverse. Lot C, e.g. requires the capacity of subline C which traverses ~~every lot, A to H~~ lots A, B, & C.

$$\frac{d}{dr}\pi r^2 = 2\pi r$$

$$\frac{du}{dv} = \frac{du}{dx}\frac{dx}{dv}$$

$$\frac{d}{dr}2\pi r = 2\pi$$

$$\frac{du}{dv} = \frac{du}{dx}\cdot\frac{1}{\frac{dv}{dx}}$$

$$\frac{d\,\pi r^2}{d\,2\pi r} = \frac{2\pi r}{2\pi} = r$$

~~The Δl costs imposed on~~

We have seen that B, upon moving to N, must pump water 3 Δl lengths, from b to n, past C, D, & N. Now, under decreasing costs, ~~These~~ the 3 lengths are not of equal cost. ~~however~~. The N-length of line N is the center and only ring of the aggregate ~~pipe~~ line; ~~traversing~~ N; the D-length is however the 2d ring, of lower cost; and the C-length is the 3d ring, cheaper yet.

But the ~~cost of~~ pipe traversing lot B consists also of a first, 2d & 3d ring, serving lots C, D, & N respectively. So again the traversal costs for all beyond lot B equal the costs of extending service to lot N.

It is also still true that we may regard the addition of subline N as equivalent to breaking the pipe at b and shifting the rt. section bodily one length uphill. For this would result in the line's becoming one ring thicker at every point right of b, which is exactly the result of adding line N.

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

Water will certainly be subject to diminishing returns on each lot -- still, as usual, regarded as homogeneous. ~~Demand~~ Demand curves at each point will slope negatively. Therefore when B ~~completes~~ relegates on his ~~begins to~~ lot N he will not take as much water as before, since prices are higher at turnout n than at b. Subline N will ~~therefore~~ be smaller than previously assumed,

(and pumping costs ~~will be~~ correspondingly less). ~~Length~~

Traversal costs of B will now be larger than ~~costs~~ extension costs of subline N, because lots C & D take more water than lot N. But it remains true that B-traversal costs = ~~the losses suffered by B,~~ ~~B's subline N extension costs~~, as will now be shown.

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

Fig. 3 shows the basis of delivering water to the several turnouts under our assumption of constant costs. The demand schedule ~~curve shows the value of various~~ applies alike to each lot under our assumption of homogeneous lots. Each cell reps. the cost of

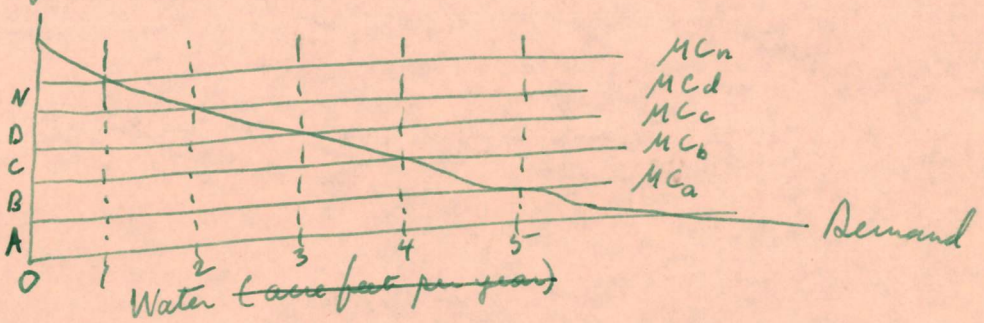


Fig. 3

~~carrying~~ one lot ~~subline~~ length of one ~~subline~~ unit of capacity. Each cell-row between ord. & d-curve reps the cost of traversing each lot with its own supply. Row a, e.g., reps cost of the 5 units taken by a carried past lot 1. (from source to turnout a.)

Each cell-row plus the rows above it and under the demand curve ~~represents the cost of~~ = (altho it does not specifically represent) the total traversal cost of the corresponding lot. Thus cost of traversing A, e.g., is the full triangle under the d curve (ignoring the small half-cell triangles, ~~made by the~~ which become negligibly ~~small~~ as the units become small). Part A must go 5 units for a, 4 for B, 3 for C, 2 for D, and 1 for N.

The costs of traversing lot B, ~~on~~ which our present example focuses, are first equal to ~~represented by~~ cell-rows B, C, & D, (they are specifically repd. by cell B1 × 3, B2 × 3, + B3 × 2, + B4.) ~~that is the entire area under the d curve above cell~~ MCa, comprising 9 cells. ~~This equals the sum of losses suffered by B in moving to lot N~~ After B moves to lot N, turnout b is closed and replaced by n, ~~so traversal costs~~ which takes only one instead of 4 water-units, so traversal costs fall to 6 cells; equal to rows C, D, & N. (3 × B1, 2 × B2, and B3.)

The extra cost of extending service to B at lot N is the 3 cells C1, D1, & N1, repg the costs of carrying one water-unit past 3 lots on subline N.1 At first blush this makes it appear that B's losses are less than traversal costs, but B's losses are greater, ~~than his traversal cost~~ for he was ~~losing something~~ gaining 2 cells worth of net rent from the 2d water unit, and one cell from the 3d. These 3 cells of lost rent (C2, D2, and C3) bring his losses up to 6 cells, equal to the ~~traversal~~ costs of traversing B.

Now let us again drop the assumption of constant costs. It can be shown that traversal costs still = Σ of B's losses. (To be expanded).

Finally let us drop the assumption of homogeneous land. We now have a situation wherein traversal costs are to be blamed on Nature as well as man. Suppose B is rough land with low carrying capacity (& hi traversal costs). The losses imposed on B are much lower than under homog. assumption, and ∴ clearly less than traversal costs. It can be shown they are = to what traversal costs wd be if the land beyond B was of the same low quality as B.

In gen'l it is true that land nearer system centers is of higher quality than land farther out. Land nearest the city waterworks, e.g., is probably also nearer the telephone central, power distribution center, gas tanks, commercial center etc etc. It is probably also true, ∴, that losses imposed on outlanders by the occupancy of central land not only = the traversal costs but exceed them: they = the traversal costs that wd. obtain if far out land were of equal quality.

Summarizing, losses (imposed on society by extension in space) may gen'ly be aggregated in losses suffered by one individ. who is assumed displaced to end of system. This individual will tend to bid up the price of land intramgnl to the point that it serves as an effective constraint.

on extensions in space. This outcome depends on pricing of xpta services optimally, such that social costs are exactly reflected in pvt. costs.

---

c. The aggregate constraint on system extension

Keeps systems ~~confined~~ compact

Not just ~~keep~~ sift uses w-in a xpt framework; use given framework best

down size of xpt net

d. Constraint on motions. Important pacifistic force.

Where system doesn't ~~thru~~ arrange for full ec. rental constraints at center, pops move out, clashes.

Was a time we cd. justify expansive bias of our instns by assumed needs of manifest destiny, occupy continent quickly & preempt it from rival empire builders. at least w. skeleton crews, Cities & universities & corps still do. Today problem is rather one of orgg viable domestic ec., cultivating our own gardens

~~d. Mgmt rent vs. own. rent~~

~~Against what~~ force is the constraint ~~contradicting~~?

consolidg our gains, ~~temper~~ finding internal outlets for our aggressions. ~~Is our culture implants in us all~~

Not merely isolationist force. No constraint on ~~going~~ faring forth as merchants & tourists.

~~Rent theories~~

III, D. Rent as a constraint on extension in time.

1. We have seen how rent serves to check unlimited extension in space, i.e. to alloc. land among adjoining uses. It also serves to allocate land among successive uses, i.e. to ~~it serves to~~ ~~to one~~ analogously to check unlimited extensions of use in time. Extension in space, w. fixed compl. inputs, obviously reduces intensity of land use by combining more land w. same ~~bldg, labor~~ improvement. It is a little less obvious, but = ly imptnt, may achieve same end by encroach'g on the time mgn of land use, i.e. by letting bldgs ~~grow~~ ~~old~~ depreciate & remain at a low value for many yrs before replac'g them. ~~Only constraint on this is rent. (to ½)~~

Points to make, no order.

1. Other inputs decr. cost, but not land. ~~Yield~~ If overlook, spurious ecs of durability.
2. ~~Yield to rent~~ Future rent does it. Present rent not distinguishable. Thus land is under pressure from inside as well as outside a firm.
3. When future net rent = current gross rent, determines timing of replacement of improvements
4. W/o rent, never demolish, use shacks for hay or old tools. Future rent is MC of time, if only land has salvage value in current use. Rent is only MC of time, except int. on salvage value.
5. Future rent depends on life; depends in turn on rent of 3rd stage, etc. ~~Bldgs~~ If identical future, simul = n. In practice, one or 2 stages enough. Unless rotations short, then ~~use inf series~~ they are more predictable, use inf. series.

~~6. Is fn. of allocating land among successive uses.~~

7. Faster turnover is means of intensification, using 4th dim., & rent encourages it. Rent doesn't encourage durability, so much but speed & flexibility
8. Defender & challenger. Terborgh (from Hotelling? Check Semin note)
9. Profound effect of rents and/or land prices on aggreg. ec. activity via turnover of cap. Thus cycle of land prices affects macro-ec.

The primary constraint on this temporal extension is rent, which one may view as part of the nec of time. Rent puts land use under pressure not just from the side but from the future. Rent is not of course the only nec of time — all costs have a time vector. But rent behaves in time as in space, that is it holds up inexorably at a constant level as one approaches the margins of decision where other inputs taper off.

An important exception to this pattern is comprised by biological capital, such like trees & cattle, which appreciate over time. Even with such forms of appreciating capital, rent remains a constraint on temporal extension, even tho not the only or even the most important one. It is ironic that in the field of the function of rent (our) But the more usual improvement on land depreciates & obsolesces over time and has little, no, or negative salvage value in its later years. W/o rent such bldgs wd almost never be demolished. On a base of zero, any return is infinite. Along Park Ave. today a sound 30-story bldg in good has just fallen under the wrecker's ball to relegate the site for a larger, newer improvement. The same bldg in St. Louis, or even in another section of Manhattan, might last another 50 yrs; in Aberdeen, S.D., longa; in Malta Bend, Mo., 300. Outside a city it wd. last 150 yrs: ~~One in Farm, [illegible] 1,000 yrs~~ fall of its own weight, for even when it cd. always be used for storing grain, or old equipment, & ultimately for dispersing of junk. There is always some use, however humble, for an old building. If it has no salvage value other than the site, & the site is worthless, or treated as though it were, there is no limit to economic life short of sheer physical collapse.

TP

aurogate
∞ return

as a time constraint shd have received its most explicit, extended & sophisticated treatment in ~~the field of~~ forest ecs. where its relative importance is much less than in other industries.

~~Step~~ Usual cost thy. neglects this. ~~Is timeless~~ Besides being spaceless, is timeless. Axes are labelled simply "output" or "cost" which mean output & cost annualized. Yet curves cd. not be drawn w/o assumg. explicitly or implicitly, ~~annualizn has been accomplished~~ life span has been determined.

~~Second~~ Some urban land ecnts have expounded this fn of rent, but somehow it has never found its way into the main body of mgnt. cost analysis used by ecnts. Mgnt analysis has tended to remain not ~~just~~ purely spaceless but timeless, even to the extent that cost curves & revenue curves are traditionally presented on axes labelled not "output per yr" or "costs annualized", but simply "output" & "cost". ~~In what~~ One ecnt, Bldg. who has tried to apply mgnt anal. to Time ecn has concluded ~~it does~~ — I believe wrongly — it does not work. The lit. on "capital thy." has tended to neglect both the mgnt approach & the key role of rent in ~~timing~~ ~~in~~ determining ec. life of investments. ~~It is fair to say that~~ I hope I may not be accused of preaching to the converted if I expand on the role of rent as a constraint on temporal extension.

The rental constraint on time-extension operates more specifically as ff. Let us adopt Terborgh's ~~acquisition~~ terminology & describe the old & new uses as defendant & challenger. The time to salvage an old site ~~by demolition~~ arises when the current defendant's annual income net of current operat'g costs falls below the challenger's ~~net of~~ annuity. ~~Net~~ annualized rent ~~anticipated from the optimal future~~ net of all costs. Note that we are biased for the defender bec its capital costs are already sunk ~~and irrecoverably~~ and nonsalvageable, so ~~we~~ in the input chosen we deduct no ~~depreciation or obsolescence~~ charge on sunk capital, neither depreciation, obsolescence, nor interest. What's done is done & historical costs are irrelevant, even if still embodied in outstanding debt.

The challenger's annualized net rent is a more difficult concept. A new use typically entails heavy initial costs followed by net revenues ~~ripening~~ tapering off over many future yrs. ~~until a new challenger prevails. No one of the years above is a~~ The whole cycle of investment & liquidation is an indivisible unit that must obviously be judged as a whole. No one year, the first, last, or any other, could be selected for single out.

The challenger's rent must be an average of its performance over time. A simple annual average however will not do, for ~~sign~~ time distribution of costs & revenues as well as absolute quantity is at issue. A "time-average" is necessary. This is to be found by annualizing all costs & revenues — for brevity let us henceforth say simply "net revenues" — that is by finding the amount, a, which received annually over the life would be of Net revenues in the terminal year, ~~of demolition~~ are annualized = value to the net rev. received once.

by the ff formula: $$a = \frac{i\,R_t}{(1+i)^t - 1} \qquad (3)$$

where R is net rev in year t, i. is the relevant i.r., & t is the terminal age of the improvement ~~upon demolition counting from the~~

Net revenues in any other year, $\leq t$, are annualized ~~in the same formula~~ by compound'g them forward to the terminal yr, t

We might assume the o.c. determined externally by the challenger but this wd. really be running away from an essential part of the problem. ~~for we cause~~ by assuming the challenger had solved it.

~~In~~
since the challenger in time ex is typically not another firm ~~another use~~ but a new cycle of improvement by the same firm ~~at~~ time, it wd. be most inadequate to assume away the gen., & we will pursue it.

before ~~annualizing~~ applying the annualizing ~~process~~ operation of formn. (3).

Thus the complete annualizing formula is:

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

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

TP It ~~is~~ reassuring ~~to~~ one's faith in ingul analysis to note that one way of doing so is to find the year when $R_n = a$, i.e. when mr of time (R_n) = rc of time (a) ~~here~~ ~~"a" here refers to the subsequent cycle of improvement~~ In the 1st few yrs of bldg R_1, R_2 etc may be less than a, and ordinarily will be not only that but less than 0, as heavy initial commitments are counted as negative revenues. This is inevitable in the nature of long term improvement. But toward ~~in~~ the ~~terminal~~ later years any value of R_n falling below the running time-average, a, established by preceding yrs, ~~and~~ & not rep'g a new invmt to be requited by later revenues, wd. lower the time-average of the whole, and call for ~~retirement~~ demolition & renewal.

Which is also to say that in time-analysis, as in space analysis, & as in the timeless-spaceless abstract analysis on which ~~exists~~ we cut ~~their~~ teeth, & w. which still feed their young, a marginal ~~way~~ principle intersects the corresponding ~~one~~ way for. ~~at~~ ~~the latter is max. value~~. where the latter is ~~flat.~~ ~~constant~~.

a max. ~~or a min.~~ ~~in this case a max~~.

One may object ~~that the f~~ to the foregoing that it implicitly assumes the 2d future stage will be like the first, and the objection is valid. If, as is often true, we may confidently forecast a higher rent for the 2d future stage than the first, the problem of setting the rent of the first grows a little more complex. It will be necessary to shorten the 1st life cycle ... & make appropriate optimal adjustments in type & intensity of ~~use~~ improvement --- so as to cut it off when R_1 = the higher future a. This will necessarily lower the a of future stage 1, which in turn will prescribe ~~the~~ postponing some further yet the demolition of present ~~life of~~ improvements. As future stage 1 is thus squeezed ~~from~~ both front & rear it will ~~may~~ become ec. in some conditions to abandon it entirely and move directly to stage 2, at such future time as the higher future potentialities make optimal. Thus a higher remote future rent may weaken, ~~the present~~ rent as a current constraining force on temporal extension of land use.

~~It~~ This is only a trepidation that I expand this last principle, for ~~there are~~ it is all too easily seized upon by the Panglossians to rationalize

While this last principle ... let us call it avoidance of premature commitment — has merit in some circumstances, ~~there are~~ ~~few more overworked~~ it groans beneath the heavy burdens ~~it~~ ~~is asked to~~ heaped on it by Panglossian philosophers of the

This will reduce the ~~a~~ of future stage 1, but at the same time increase the marginal value of time so that ~~it~~ the mgnl value rises above the average. It is this higher MR that ~~must be~~ is now the ~~time~~ o.c. of land-time. The optimal mgnl adjustment would therefore be to accelerate demolition and renewal.

This adjustment is optimal however only to a point, for as the mgnl. time value of future stage 1 rises, the time-anc. falls. At some point the time-anc falls below that which the present use wd. yield over the same pd and it becomes optimal to skip future stage 1 altogether, proceeding directly to stage 2. In fact to skip stage 1 becomes opt. ~~even a little~~ before the point just described ~~because in light of the possibility of accelerating stage 2~~ if skipping stage 1 will accelerate the inception of stage 2, with its antic. higher rents.

Antic. higher future rents ∴ will tend to Δ the constraining force of rent up to some point, but ~~then~~ relax it greatly if the anticipations prescribe skipping future stage 1.

The use of this argument by some ~~land~~ econ has tended to be ~~quite~~ unbalanced, with emphasis largely on the removal of the rental constraint by a too-easily presumed desirability of skipping ~~stage~~ challenged 1. The principle of avoid'g premature commitment ~~growns~~ beneath the burdens over it is asked to bear. ~~by Pangloss the disciples of Dr. Pangloss~~ ~~heaped on it by Panglossian philosophers~~ At the hands of R.T. Ely it served to rationalize unlimited waste of land-time in the ~~land speculative~~ urge to ~~speculate~~ ~~bequeath into little space~~ ~~If a testator instructs~~ is Panglossian ~~using rules~~ of the 1920s.

Maximal architecture

~~the~~ ~~them pie-in-the-sky.~~ [Ely's excesses should not blind us to the real merits of the position and lead us swings to the other extreme. ~~to~~

P When a comprehensive realistic analysis of future prospects truly prescribes skipping stage 1, then by all means let us be gentle as doves & accept avoidance of premature commitment as ex. justification for retention of obsolete & decayed ~~defenders~~ improvements on valuable land. But let us also be ~~acutely~~ wise as serpents and habitually skeptical of an argument that lends itself so neatly to pie-in-the-sky rationalizations from the disciples of Dr. Pangloss. There are other & less defensible causes for waste of land in rising mkts., as we have seen (or will see)

~~Aside from this exceptional case we may grudge that~~

3. Rent & intensity thru time.

The accelerated replacement constrained by rent is a form of intensification of land use, as one ~~might~~ would expect. from the ops of a land constraint.

Outline: a. ~~His~~ constraint ~~on~~ low input/yr, time use of costs, ⊆.

b. Intensity is of a sort not always obvious at a moment of time. Higher rent may sometimes even call for lower initial costs. ~~cropping~~ faster turnover. On balance does it ~~drop~~ more & cumulatively so. (over) Emphasis on speed & flexibility, rather than ponderous monument ~~Fast~~ turnover. Pervasive.

c. ~~Does~~ not carry this principle to indefensible extremes however. Its tendency to ~~enforce~~ ~~away~~ ~~but~~ high turnover economy as emphas w. the "fast buck", shoddy goods & jerry bldg.

Rent is an optimizing concept strikes balance between claims of quality & speed.

Best seen by separating Rx. net rev. into + & - parts. 2 curves

to get full rent from site. But considering time aspect alone, chopp's off end of cycle tempers tendency toward heavier improvements.

W/o the constraint the individual's motivation wd. be to squeeze the last drop of income from ~~his~~ initial outputs ~~improvements~~ by spreading them over as much ~~time~~ land-time as they would endure, thus minimizing the time-average of his costs w/o regard to the time-ave. of his receipts.

The intensity that the time-constraint encourages is of a sort, ~~however~~, that is not very obvious ~~if we should~~ at any given pt. of time. ~~observe the state~~ The intensity of land-improvement value ratio takes the form of faster turnover of improvements rather than heavier initial improvements. Rent as a spatial constraint prompts heavier improvements, but rent as a temporal constraint, chopping off the end of each cycle of improvement & use, ~~has a tempering influence on initial costs. It puts an emphasis rather penalizes the ponderous & monumental, and~~ puts a premium rather on quick recoverability of capital, on flexibility & speedy turnover. ~~The joint result of the spatial & temporal constraints is "volume", the product of intensity times turnover~~ ~~It does this by limiting the no. of yrs over~~ ~~which initial costs may be spread.~~ ~~The combn. of intensity and~~ ~~The combined result of the spatial & temporal constraints is volume.~~

This influence of rent is pervasive, affects not only buildings ~~& orchards~~ but the daily use of rooms & shelves & flows in buildings. Rent is no less the executioner of the creaking machine and the tired orchard. A hi-rent ~~slum shack~~ firetrap apartment and ~~and~~ economy is one with emphasis on speed, in all economic activities, phases of life.

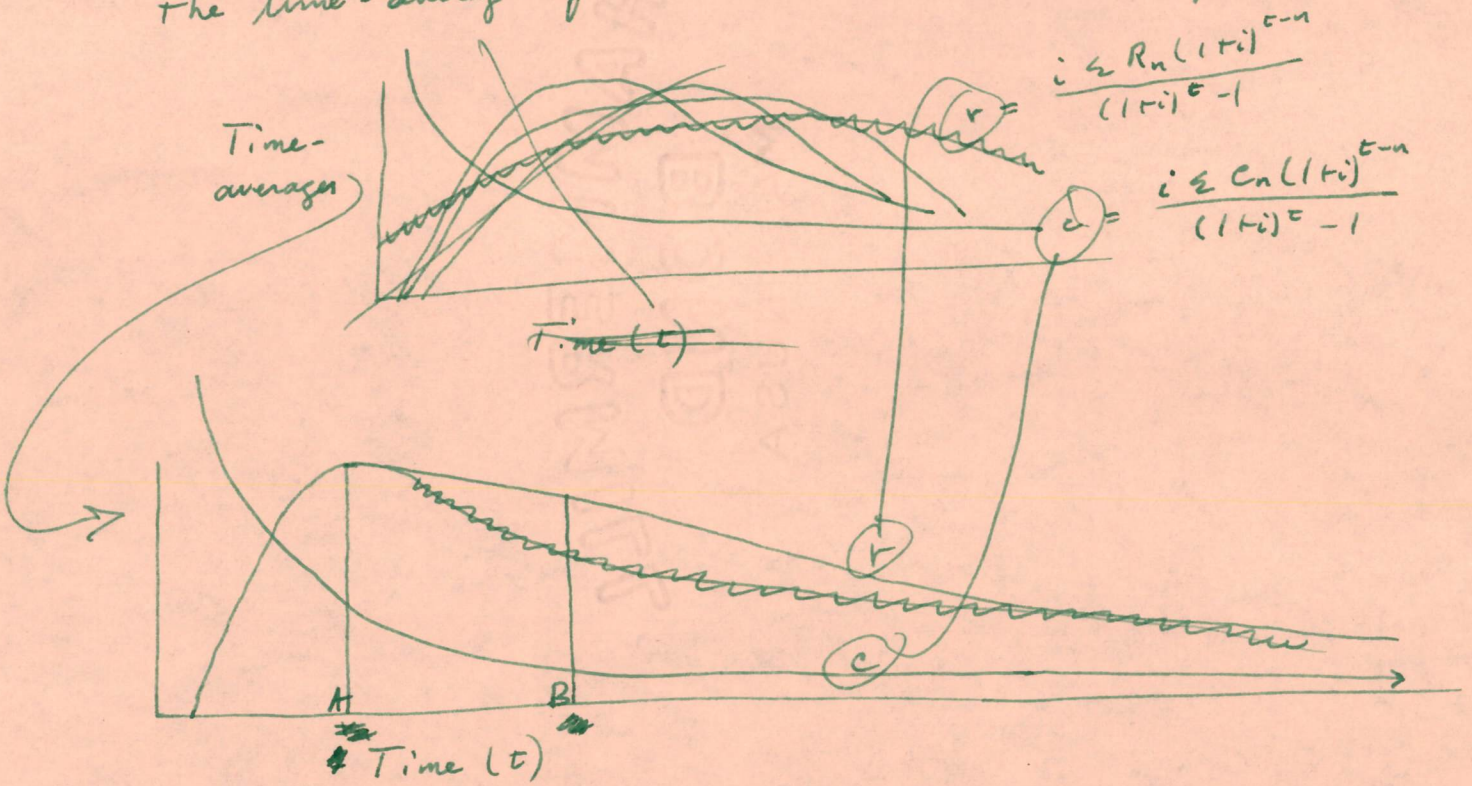
~~There is a limit~~

~~The temporal constraint of rent does not~~

Rent is not entirely the enemy of quality, substance & durability, however. ~~It puts a premium not just on turnover but on volume, the product of turnover times quantity.~~ It is an optimizing force that abhors extremes. While it does not let the minimization of time-ave. costs dominate ~~all other~~

It penalizes the ponderous & monumental and so has rather a tempering effect on initial costs. Its influence is rather toward maximizing volume of business, the product of quantity of capital times turnover.

~~considerations, neither does it neglect~~
decisions to the extent of ignoring time-anc. revenues, neither does it the opposite. It rather strikes a golden mean ~~where the~~ maximizing the excess of time-anc revenues over time-anc costs. $\eta_n = n(\ )$ we submerged this relationship by combing revs. & costs in one expression, ~~for~~ net rev. (R_n). Let us now expose them separately and observe graphically the typical interplay of ~~the~~ the time-averages of costs & revs w. a life of improvements.



~~Rent is not r here, but r = c.~~

Here we see the same principle as in Fig. 3 applied to time instead of space. The rental constraint ~~drives us back~~ precludes indefinite rightward drift, ~~but it~~ because time-anc. revs are falling. But it does not drive us clear back to the max. of time-anc. revenues at A, for there time-anc. costs are too high. It drives us rather to B, where ~~around rent~~ the curves are 11 & farthest

apart, & net annual gain is a max.

4. Rent as a constraint on economies of scale

Rent in its temporal aspect tends, to limit economies of scale just as in its spatial aspect. Decreasing costs arise largely from the imperfect divisibility of fixed capital inputs. Decreasing costs are realized by spreading these over space. Decreasing costs are also realized by spreading these fixed cap. costs over time. Large captl. inputs tend to require the complementation of more land-time as well as space, because size is associated w. durability and long preliminary planning, assembly & construction periods. as fixed cap. inputs are spread over more land time there are realized decreasing ave. time costs. (E.g. —) But there are increasing no decreasing land time-costs. They are more likely to rise.

Large fully integrated mills, factories, urb projects . . . etc. promise impressive ecs. of which it is easy to become enamored. But many of these ecs. rest on the implicit presumption that heavy initial fixed costs may be spread over ample future time. Limit that future spread and many a mammoth becomes a white elephant. ~~that is economical.~~

Being a form of intensification, the faster turnover constrained by rent tends to save space for society, i.e. a higher rent keeps a larger volume of cap., averaged over the years, on a given site; it gives more frequent employment to construction labor & most probably a higher level of other employt over the yrs; & it yields more consumer satisfaction. Thus it provides more employt, & more opps & consum on given space & relieves the pressure to expand onto new lands. Conversely, over the availability of new lands relieves the old of much of that old land's return requirement on rental constraint on the use of land-time, & lets lands, once improved, degenerate into economic deserts. Removes the incentive to salvage sites for new use

A reason some of the worst slums in the western world are found in older Am. cities is essentially the same reason we have produced some of the world's most abused farm land: Ours has been a migratory culture. By subsidizing Not only have we had a continent to settle, we have subsidized one new form of xptn after another, relieving individuals on peripheral city locations of much of the ec. disadvantages of their locations and spreading them the ec. rent that wd. otherwise have arisen on older sites. Let me not overstate the case — there are opposing forces, and many partly successful efforts to maintain artificial security of older lands. On balance however our culture & political system of regional representation seems attuned to making accessible an abundance of land — "artificial" in the sense it is more than economic reasoning wd. prescribe. The result has been exploitation at the fringes & stagnation in the older centers, both reflecting

We may speak loosely of "high rents driving people ~~away~~ out," but more accurately it is the scarcity of land, natural or artificial, that drives people out. Rent, conceived as a constraint on the landholder, minimizes the outward thrust necessitated by land scarcity. It is accurate to speak of hi rents dispersing population only in the sense that asking ~~rents~~ prices for land may be higher than anyone ~~can~~ unpeditingly can bid, but that is another matter.

low rental constraints on land use.

6. Macro-ec. effects

It is ~~sometimes~~ hardly remembered today that macro-ec. thg, as foreshadowed in the writings of Wicksell, began as a study of the ~~real~~ rate of turnover of an ~~nation~~ economy's real capital stock. Now ~~we~~ economists have become so involved in the details of manipulating monetary flows we are in danger of overlooking other influences on turnover. One of these is the level of ground rents. From foregoing pages it is evident these must profoundly influence the ~~turnover rate~~ time-rate of capital ~~as~~ turnover, and thereby influence the aggregate of economic activity.

If ground rents were a static factor we might treat them as a given. ~~In fact they are the opposite, very changeable~~. Viscous they may be, but static, no. The ups & downs of l.v. in fact over a long cycle of ~~thg~~ about 30 yrs are matched by few if any other ~~prices~~ commodity prices, & certainly by none of comparable ~~importance~~ aggreg value. It is hard to imagine that these ~~large changes~~ great swings in the price of land-time have no significant effect on the time-rate of turnover of capital applied to land, and thereby on aggregate economic activity.

Now "put the case Mr. Pip" that ~~When l.v.~~ ~~If~~ the nation's capital stock were spread so thin over so much land that land had no rent. Then ~~the~~ its stock would

~~Now "put the case, Mr. Pip", that l.v. the present system has practiced & encouraged is reacting l.v. and collapse next yr as they have on some ill-starred occasions in the past.~~

turn over very slowly. In a typical boom cycle, population & capital do move out from established centers, ~~and along new~~ aided by new ferms of xptn, and spread themselves ~~to~~ thin. This wrong at the time. H. l.v. at the old center speed the recovery of cap. from older sites to help finance the new expansion. They do this to the ~~accompaniment of rising l.v. whose annual increments help offset the constraints of rent & forestall the renewal of much land.~~

But these process ultimately brings so much land into the mkt. as ~~to~~ not only to stop the rise of land values but reverse it. and return land to low values. This leaves so much ~~quite a share of~~ the nation's capital ~~frozen~~ spread so thin over so much land of so little value as to ~~pace~~ freeze the capital nearly solid, irrecoverable.

Can this process fail to check economic activity? I think not. The full ~~exploration of~~ pursuit of this question lies beyond our present scope, but it does suggest that the implications are far reaching indeed of rent as a constraint on land-tim. ~~of all the questions raised~~ ~~in~~ ~~ec. gen~~ related to rent this ~~one~~ is surely ~~most~~ urgent to study. If these remarks will ~~serve to~~ arouse some interest among ~~bus~~ cycle analysts they will have served a purpose

at first, and for a long time to the accompaniment of high & rising h.v.

Chapter 5

"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 highest 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 advanced 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 economically occupy; and still less attention to the social rationale for the spatial constraint in terms of transportation 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 at the urban fringes were less than social 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 the 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 perpetuatethe 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. Indicative of this, there are internal inconsistencies in the major writers which suggest a less than complete appreciation for the implications of some of their principles. Isard at one point (p. 193) shows, following Dunn, how high central rents cause substitution of other inputs for land and increase intensity. Yet earlier he had referred to high central rents as deglomerative factors, following Weber (p. 183.)

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 in discussing 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 pre-empting 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 by 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 one 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 ~~Product~~ 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

conventional
any average product curve, showing the result of varying proportions on output.

Typist: put in figure from p. III - 8½, attached.

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

The difference of AGP 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.

(OVER)

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 ret revenues 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 to 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 ~~of course~~ not sufficient) condition of rent-paying capacity; and the rental constraint forces intensification on those who must meet it.

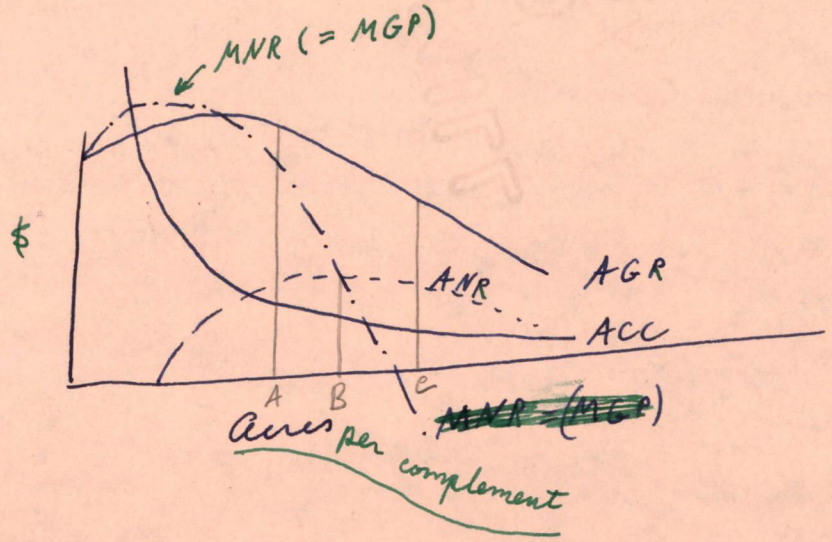
The observation of extensive land uses persisting in central places on valuable sites has seemed to call for rationalizations, which have tended to obscure this necessary strict relationship between intensity and rent-paying capacity. However the economist's job is not just to rationalize what he observes 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.

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.

(Note to typist: Table 1 attached)

III - 8½

This is ~~really about what it looks like~~.



It is rarely stressed how fast the mp of land drops off as the AP falls. Use these figures to illustrate. But make them stronger by beginning lower, getting sharper AP returns at first. Note, around Max ANP, high contrast of MNP above & below. E.g. at 5 acres & 10 acres, ANP = 2.0, but MP = 8 & -2

Land (acres)	AGR (1)	GR (2)	MGP‡ MNR (3)	cc (4)	acc (5)	ANP (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

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

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

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 "extensity" abstracted from scale. In the process it assumes a peculiarly important role as an absolute limit on scale because it 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 he acquires be 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 economic 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 location 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. Such specification also forms a necessary background to our later consideration of the divergence of private from social transport costs, and its effects.

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.

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 are 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 trianges, 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.

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 extensity 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.

III. (?) 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 reduces intensity 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 trees/or 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 attached/to occupying land depreciates and obsolesces with time and has little, no, or negative salvage value toward its senility. Without rent old buildings would stand almost never be demolished. On a base of zero any return is infinite. Along Park Avenue today a 30-story 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 building/will 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 biassed 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:

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

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:

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

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 ~~even~~ ordinarily will be even less than zero as the initial costs are count d 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, ~~we may~~ 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 a , of the time-average rent of challenger #1. This might seem to weaken its challenge to the present defender and call for 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, 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.

The zone of choice by some economists

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 1920s.

Ely's excesses should not blind us to the real merits of the position. When a comprehensive and realistic 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 ~~so easily~~ to pie-in-the-sky pronouncements 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 ti e-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 __)

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

Here we see the same principle as in Figure __ 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 __). 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 statewide 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 lands 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.

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

The reason 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 downs 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.