ACCESS AND LAND DEVELOPMENT

MORTON SCHNEIDER*

The starting point of this paper is a modest mathematical observation concerning the relation between the number of trips emanating from any elementary area and the geography in which the area is embedded. It has been possible, or has seemed so, to trace out from that beginning a line of thought —intercalating an assumption here, forcing an argument there—leading to a more or less coherent view of how people move about and where they build their works.

The framework of ideas given here is complete in the sense that one can think of fleshing it out into a working, computerized model for calculating expected patterns of floor area accrual and traffic on facilities of all modes, as indeed one has thought of doing. But it is by no means perfectly clear that these ideas are really tenable. There is still a certain amount of computational sneaking up on a full scale model to be done, and it is the purpose of this paper to lay a basic, if diffident, case rather than to report on a methodology or to stumble around in a clutter of possible complications. The treatment here will stick mostly to main features and long, untroubled perspectives on the grounds that, for the time being, enough is enough.

ACCESS AND TRIP GENERATION

It is quite usual, in analyzing travel, to suppose that every piece of the earth's surface has some stipulated supply of trip ends per day, and to assert that the number of trips between an origin place and a destination place is proportional to the number of origin trip ends, to the number of destination trip ends, and to a function of the separation between origin and destination. A slight generalization of this is

$$V_{ij} = \frac{V_i F_{ij} R_j}{I_i} \tag{1}$$

Where V is number of trips, F is the function of separation, and I_i is $\Sigma F_{ij} R_j$ (or, more neatly, $I = \int F dR$). R is an undefined quantity measuring that which attracts people to a place; it will not become defined until much later on in the paper, if then. If V_j, or something proportional to it, were substituted for R_j, Eq. 1 would represent virtually every trip interchange formula ever used. However, the distinction is not as trivial as it looks.

* Director of Research, Tri-State Transportation Commission

Viewed as a destination place, any small area receiving trips from the rest of the world according to Eq. 1 will receive some very definite number of trips, and this must be essentially the same over the course of a period such as an average day (neglecting migration effects) as the number of trips it sends out. It appears, then, that if Eq. 1 has any validity—and it is so general it almost has to—the generation of trip origins or destinations cannot really be prescribed by arbitrary manipulation, but is subject to some kind of natural equilibrium. The obvious next step is to add up all of the trips received by an area in order to see how many must originate there; but it is a great deal less obvious just how to go about this in any meaningful way. As it happens, though, the problem yields with astonishing ease to a little simple-mindedness.

One condition, reasonably well supported by both intuition and data, which logically guarantees the equality everywhere of origins and destinations is that trip movements between any two points be symmetrical; that is, that V_{ij} always equals V_{ji}. If this is taken to be true, then, working Eq. 1:

$$\frac{V_i F_{ij} R_j}{I_i} = \frac{V_j F_{ji} R_i}{I_j} \tag{2}$$

If it is further assumed that F is symmetrical, that $F_{ij} = F_{ji}$. The F's cancel out and this can be restated as:

$$\frac{V_i}{R_i I_i} = \frac{V_j}{R_j I_j} \tag{3}$$

But this cannot hold for all pairs of points unless each side of the equation is separately equal to the same constant, a circumstance that gives rise to the general and possibly important result

$$\frac{V}{R} = cI \tag{4a}$$

or, passing to notation more comfortable for dealing with indefinite but relatively fine partitioning,

$$\frac{dV}{dR} = cI \tag{4b}$$

So with hardly any trouble at all, it develops that trip density at a point in terms of origins (or destinations) per unit of R, whatever R may be, is proportional to something that can very naturally be called the access integral around the point. By integrating Eq. 4b, the constant of proportionality can be seen to be a special kind of average density:

$$c = \frac{V_T}{\int I dR} \tag{5}$$

where V_T is total trips in the system. This constant will be evaluated in a somewhat different, but equivalent, form later on from other considerations.

Another way of stating Eqs. 4*a* and 4*b*, in words, is that the number of trips at a point is proportional to the accessibility of the point and to its attractiveness to people; trip ends appear at a place because people can and want to get there. This is a small shift from the customary point of view in which trips are thought of as occurring to satisfy the craving for fulfillment of trip ends. The usual proposition that travel is formed by trip ends groping for each other has never seemed to have much explanatory feel to it; as it turns out, it does not seem to have much mathematical feel to it, either. If R is replaced by V, reverting to the standard formulation, everything breaks down; the sent-received balance described by Eq. 2 can then obtain only in a world so uniform that every access integral has the same value An attempt to introduce correction factors—to use quantities proportional to the V's rather than the V's themselves—works well enough as far as Eq. 2 is concerned; it is just that the required correction factors are precisely those which convert the V's back into R's, according to Eq. 4. (It can also be shown that permitting F to be non-symmetrical does not help this state of affairs.) In other words, whether or not one likes the shadowy stuff called R, one is stuck with it.

The function F, which distributes trips from an origin place among all destination places, is amenable to a simple argument. It has been said above that R measures that which attracts people to a place. Taking that at its word, the easiest supposition about where people are going when they leave some origin area is that they are going everywhere in proportion to the R-values found there. But this would result in an infinite average trip length, or as nearly infinite as the circumference of the earth will tolerate. There is one most conspicuous constraint operating: trip lengths cannot get out of hand: It is not too hard, however, to compound this constraint into the first supposition by means of a little rephrasing. If the R-value of an area, now, is taken to measure the *a priori* probability (*i.e.*, without regard to travel time or cost) that a trip will go there, then that easy first supposition can become the easy second supposition: trips leaving an origin area tend to distribute themselves among destination areas in the most probable way, subject to the condition that their average length must remain finite. A perfectly definite function can be derived from this statement.[1] If travel occurs in the dimensions of time and cost, this function is

$$F = e^{-(k_1 t + k_2 u)} \tag{6}$$

where t is travel time and u is travel cost; the k's are constants governing average length. And, to recapitulate, the access integral becomes

$$I = \int e^{-(k_1 t + k_2 u)}\, dR \tag{7}$$

where the integration, of course, is over the whole surface of the earth or some other large region.

---

[1] See the section on the Distribution Function in Morton Schneider, "Direct Estimation of Traffic Volume at a Point," Highway Research Record 165, 1967.

An interesting aside is the relation of all this to the method of calculating traffic described in the reference cited above. The arguments there, with one exception, can be carried out exactly as before merely by replacing integration over trip ends with integration over R The exception is a crucial one, however: it is no longer permissible to arbitrarily place a single trip destination in the vicinity of the traffic stream. It is necessary, instead, to place an arbitrary amount of R there and let it generate its own proper number of destinations (or, the same thing, the correct amount of R to generate one destination). When this is done, the formulation is altered in such a way that its one apparently fundamental flaw miraculously vanishes. In its original form, the formula calculates systematically different (but not greatly different) traffic volumes at different points along a bridge; altered, it produces exactly the same volume at every point. Another, perhaps more generally interesting, connection is that the revised traffic equation contains the constant c of Eqs. 4 and 5, but no other explicit dependence on trip ends. In principle, c could be numerically evaluated as a kind of activity constant from a study of traffic flows, and travel could then be calculated without once mentioning trips.

It is not very usual, in analyzing travel, to speculate on the exact meaning of the word trip, but it really cannot be avoided forever. Trips here are used to some extent as concepts of convenience, neither very interesting nor very observable in themselves, having whatever properties the mathematical treatment generates and being roughly similar to, though far more inclusive than, those things reported in an origin-destination survey. There is more to it than that, however. One property a trip must have, if only to give meaning to the terms travel time and travel cost, is that of defining travel: knowledge of an origin and destination must imply knowledge of the travel path between them. This suggests, as does common understanding, that the end points of trips are set apart from all the other points along the way and that perhaps these other points are there only to be traversed as easily as possible. Which is to say that trips follow minimum paths because it is very hard to think of any other rule that allows the trip concept to be useful. So trips can be defined strictly, if unsentimentally, as segments of a person's total travel trajectory that lie entirely on minimum paths, and those points at which departures from minimum paths occur are necessarily trip ends. The travel times and costs in the trip distribution function (Eq. 6) are to be measured along minimum paths, since if the trips take any other paths, they are not trips.

Now that the question, "what is a trip?" has been settled, it becomes possible to move on to the next issue. What is a minimum path?

MODE OF TRAVEL

For the purposes of this paper, it appears inescapable to speak simply of minimum paths in order to speak of parameters such as time and cost separating points in geography. But just what is it that a minimum path, in the trip defining sense, minimizes? If travel time alone, everyone would charter helicopters; if travel cost, everyone would walk. More likely, the quantity to be minimized is some combination of time and cost. But the distribution function (Eq. 6) has already stated that trip making is sensitive to a linear combination of time and cost, so what better bet than that this is the path discriminating measure? The minimum path between any two points can now be selected from among all possible paths: it is the one for which the exponent in Eq. 6, $k_1t + k_2u$, has the least value

Incidentally, travel time and cost are considered throughout this paper to be the only generally significant distances, as seems to be the case empirically. Everything could, however, be extended to include other dimensions.

Minimum paths are now clearly defined and only one difficulty remains. In the real world, trips between two points do not by any means always choose the same path, nor can this always be explained by dispersion of indeterminacy of travel times and costs. However, the quantity $k_1t + k_2u$ suggests that the path selected as a minimum depends on the values of k_1 and k_2, and this leads to the conjecture that there are different trip groups which respond to different values of the k's, weighing time and money and the trade-off between them differently. Running through spectra of values for the two k's, it appears that between any two places there might very well be more than one path that could function as a minimum during some intervals of k-values, but not all conceivable paths could so function. The test is this: if a path is *both* slower and more expensive than some other path, no values of the k's can ever make a minimum of it and, presumably, no trip will ever use it. Paths which pass this test, which can hope to be used, can be ranked in order of increasing travel time and then in order of decreasing travel cost, and will have the same rank in both cases. Proceeding down such an ordered list of paths—call them path a, path b, etc.—it is easy to see that path a, which is the fastest and most expensive path (involving, perhaps, an airplane), will be the minimum path as long as

$$0 \leq k_2 < k_1 \frac{(t_b - t_a)}{(u_a - u_b)} \tag{8a}$$

path b will become the minimum in the range

$$k_1 \frac{(t_b - t_a)}{(u_a - u_b)} < k_2 < k_1 \frac{(t_c - t_b)}{(u_b - u_c)} \tag{8b}$$

and so on down to the slowest, cheapest path (*e.g.*, walking)

$$k_1 \frac{(t_n - t_m)}{(u_m - u_n)} < k_2 \leq \infty \tag{8c}$$

In general the breakpoints—the k-values at which one path stops being a minimum and the next takes over—occur when

$$k_2 = \frac{\Delta_{nm}t}{\Delta_{mn}u} k_1 \tag{8d}$$

Paths of this sort seem to deserve to be called modes, though the term takes on a slightly exotic meaning. A mode, in this sense, will not necessarily retain its identity from one pair of points to another, and it will not necessarily correspond to ordinary usage; an expressway route and an arterial route between two points, for example, might very well function as competing modes.

If the distribution of trips with respect to values of k_1 and k_2—the probability of a trip falling within an interval $dk_1\, dk_2$—could be established, all of this would begin to form an intelligible picture. The problem can be attacked in much the same way as that of the distribution function in the preceding section, although it fights back a little harder. Essentially the same constraint operates here as in that case: however trips may be distributed among k-values, it must be in such a way that over all average trip length stays within reason. If the distributions with respect to k_1 and k_2 are assumed to be independent of each other (not a strictly necessary condition), it should be possible to develop each distribution separately, as though the other were not there. Adopting this attitude of ignoring one dimension when dealing with the other, the crucial parameter directly controlling average trip length for any particular value of k is $1/k$, and it is plausible to think of applying the constraint in the form

$$\sum V_k \cdot \frac{1}{k} = \text{finite constant}$$

At the same time it is plausible to think of $1/k$, which has the dimension of length, as constituting a one-dimensional space within which trips are equally likely, *a priori,* to distribute themselves everywhere. And the plausible result, finally, is

$$dV = \frac{1}{k^2} e^{-a/k}\, dk \tag{9a}$$

or, adding the other dimension,

$$dV = \frac{1}{k_1{}^2} e^{-a/k_1} \frac{1}{k_2{}^2} e^{-b/k_2}\, dk_1\, dk_2 \tag{9b}$$

where a and b are constants of the distribution.

With a little semantic exertion, all of this can be carried out at the same time as the derivation of Eq. 6, and the distribution function becomes

$$F = \frac{1}{k_1{}^2} e^{-(k_1 t + a/k_1)} \frac{1}{k_2{}^2} e^{-(k_2 u + b/k_2)} \tag{10}$$

Other variations on this theme are entertainable, but it appears at the moment that they would not and should not give strikingly different results. This one follows the principle of least complication without good reason for more. Good reason might, of course, turn up at any time.

The complete distribution function as it operates between two points, referring to relations (Eq. 8), is

$$G = \int_0^{\infty}\left(\int_0^{Z_{ba}} Fdk_2 + \int_{Z_{ba}}^{Z_{cb}} Fdk_2 + \ldots + \int_{Z_{nm}}^{\infty} Fdk_2\right) dk_1 \qquad (11)$$

where the F is, of course, that of (Eq. 10) and the Z's are the mode breakpoints of Eq. 8d, $Z_{nm} = \frac{\Delta_{nm}t}{\Delta_{nm}u} k_1$.

The integrals are broken into pieces as the travel paths shift from one to another, causing the times and costs to change. If the transportation network is symmetric, if the same paths exist in one direction as the other (as has been tacitly assumed all along), then the mode points will be the same in both directions and G will be symmetric, allowing the trip generation argument to go on as before. The only difference is that the I of Eqs. 4 and 7 must be replaced with

$$I = \int G\, dR \qquad (12)$$

If a transportation system consists of distinct, noninterconnecting uniform networks, each network will constitute a mode in both the special and the ordinary sense, and trip generation at any point by each mode will be proportional to that mode's respective piece of Eq. 11 integrated out over the world of R. Examining this closely reveals an interesting and fortunate character: if a new mode is added to the system, it will attract trips from its neighboring modes but it will also increase the total trips generated However, the closer it is in speed and cost to some other mode, the less the increment of trip generation. Thus as more and more modes are added, crowding in on each other, they will more and more be merely competing for each other's trips rather than generating new ones of their own. Also, it goes almost without saying that the highest trip generation for a mode occurs at those places especially well served by the mode.

The case in which the above transportation system has only one mode is of special interest for purposes of trial calculating, getting the feel of the thing, and even practical approximating. In this case, the function (Eq. 11) simplifies to:

$$G = \int_0^{\infty}\int_0^{\infty} Fdk_2\, dk_1 \qquad (13)$$

and this, if the author's rheumatic mathematical agility has not betrayed him, is integrable, giving

$$G = 4\sqrt{\frac{tu}{ab}}\, K_1\left(2\sqrt{at}\right) K_1\left(2\sqrt{bu}\right) \qquad (14)$$

K_1 is conventional notation for the modified bessel function of the second kind, order one.

The argument that trips vary in their sensitivity to time and cost has led to a distribution function substantially different than the simple exponential of Eq. 6, quite aside from any question of mode. Even if only one dimension of distance were used (implying only one mode), the distribution function would still have the form of Eq. 14, but without terms in the other dimension. The general behavior of this function is to descend more rapidly than an exponential at short distances and more slowly at long.

Thus, the large problems of travel activity—the generation of trips by mode and their distribution through a transportation system, also by mode—have been solved, or at least laid to fitful rest. Now, if only someone knew what R was.

LAND DEVELOPMENT

As far as this section of the paper is concerned, what has gone before is prologue. Its purpose has been to establish the role of the stuff called R in human activity, to define a relation between trip generation and access, and to give an exact, computable meaning to the term access. The brave purpose of this section is to introduce capital improvement of land and to tie everything together.

The first step is to ponder the nature of R. From Eq. 4, it can be said that the amount of R at a place is proportional to the trips arising there divided by the access of the place (access refers to the all-mode access of Eq. 12, not to that of Eq. 7, and so will the symbol I when it appears). This brings up the possibility of calculating R at various places where data exist to see if it can be identified with anything visible. If that were fairly easy to do, it would probably be worth trying, but it would actually be a very formidable piece of work for several technical reasons, not the least of which is the fact that the access integrals themselves depend on R. Besides, any relationship that is not fairly well anticipated is most unlikely to be found in that sort of a campaign.

Speculating on the identity of R, two immediate possibilities come to mind. One is that R is just proportional to land area, modified perhaps by the intrinsic desirability of the land for human purposes (oceans, swamps, glaciers, etc., would certainly have low rates of R per square foot) but basically a kind of geometric concept referring to the surface of the earth, to the space in which people locate. But if this were the case, the only thing that could account for the very high rate of trip generation of, for example, Manhattan, would be, according to Eq. 4, a very large access integral. While Manhattan is at the center of a dense, extensive, and many-moded transportation system, it does not seem conceivable that this alone could supply the leverage for that kind of differentiation. How different can access integrals be when land area is the only thing to be accessed?

The other first glance possibility is that R is proportional to floor area, which seems intuitively to be something that attracts people. Again, Eq. 4 doubts it, because trips per square foot of floor area would then be proportional to the access integral. Places of high accessibility would show higher trip generation rates than places of low accessibility, and a place like Manhattan would have an enormous number of trips per square foot of floor area since the access integration this time would be over a highly differentiated surface. But evidence from origin-destination and land use surveys apparently denies this. There seems to be no systematic variation in person trip generation rates per unit of floor space from place to place, and even Manhattan is about average in this measure. Of course, the trips in Eq. 4 include many events which would never be reported in an O-D survey and do not correspond exactly to survey definitions anyway. Even so, the generation due to the longer distance part of the integration in Eq. 4 ought to be at least roughly the same as survey trip generation, and although this part of the integral may not vary as much as the whole thing, it would still vary a great deal in a floor area surface.

Rather than reject land area and floor area out of hand—they are almost the only sensible candidates—it is reasonable to wonder if R might be some combination of the two. It cannot be a multiplicative combination, since that would imply that land without structures on it could never attract trips, and the world could never have gotten started moving. The simplest acceptable combination is a linear one. With this in mind, a line of reasoning begins to emerge.

In what follows, a piece of land is regarded as a kind of abstract element of spatial location, attractive to people in much the same way that an element of volume in a box is attractive to gas molecules. Floor area is used as a convenient, meaningful, and measurable (as well as measured) surrogate for capital improvement of all kinds. Possible differences in attractiveness from one piece of land to another and from one unit of floor space to another are not ruled out, but they are not stressed, either. Various costs, congestion effects, and other odds and ends that no doubt complicate the real world are considered to be largely beside the point of this paper.

Imagine a piece of vacant, but accessible, land lying fallow. If there are people in the vicinity, they will inevitably find some reason to go there and to do something on that land. This implies, by Eq. 4, that the land has some value of R. As people use the land, there will be a tendency for improvements to appear to accommodate them, to serve and augment their inscrutable purposes. But these improvements (which are in the form of floor area) will in turn tend to attract still more people. This implies that the floor area, too, has some value of R, which is easiest to think of as an additive increment. So R in general can perhaps be defined as

$$R = R_a + R_f \tag{15}$$

where R_a is proportional to land area and R_f is proportional to floor area, though the proportion need not be the same for both R's

The increment of people attracted by the increment of floor area will in their turn foster yet another increment of floor area, and so on, although this does not have to go on forever.

Although there is no pretension that the simple and occasionally labored considerations of the first two sections can really account for all the fine structure of human activity, they do seem to apply in their crude way to relatively microscopic movements; the trip generation of Eq. 4 might be construed as a close measure of activity or average occupancy of small areas—activity which determines the amount of floor space required for its accommodation. Even on the macroscopic scale of the O-D survey, as was mentioned earlier, trips are more or less proportional to floor space. Trip generation per square foot of floor area is scattered, but it seems always to be scattered around the same mean.

If it is assumed that, in the way the world works, there is some proper amount of floor space per trip, then the growth of floor space described above moves to an equilibrium, an equilibrium strictly governed by the access of the site. From Eqs. 4 and 15,

$$V = cIR = cIR_a + cIR_f \tag{16a}$$

but also, now

$$V = sR_f \tag{16b}$$

Putting these together gives

$$R_f = \frac{cIR_a}{s - cI} \tag{17}$$

From Eqs. 16*a* and 16*b*, it can be seen that

$$c = \frac{sR_F}{J} \tag{18}$$

the promised counterpart of Eq. 5; R_F is proportional to total floor area in the region and J is a notational convenience,

$$J = \int IdR \tag{19}$$

Substituting in Eq. 17 produces the final expression for equilibrium floor area at a site:

$$R_f = R_F \cdot \frac{R_a I}{J - R_F I} \tag{20}$$

This is a rather subtle expression, and it may be well to elucidate some of its elementary properties. When the access, I, is small compared to the average, the floor area will be essentially proportional to the access. As I grows large, however, the denominator in Eq. 20 becomes small, exerting a powerful leverage on floor area, powerful enough, probably, to explain a phenomenon such as Manhattan. If the world has completely uniform access everywhere, J becomes

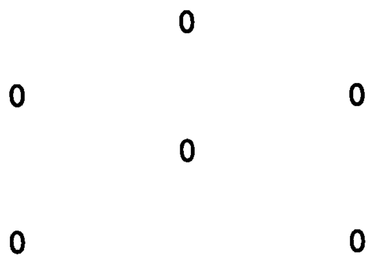
$$\int I\, dR = \int I\, dR_a + \int I\, dR_f = IR_A + IR_F \tag{21}$$

and Eq. 20 reduces to

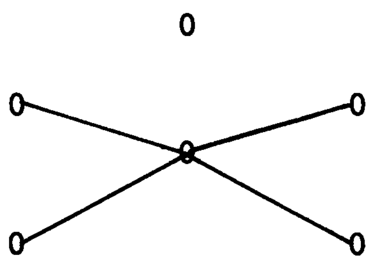
$$R_f = R_F \cdot \frac{R_a}{R_A} \tag{22}$$

The floor space on any site is just its share of total floor space based on its share of total land area.

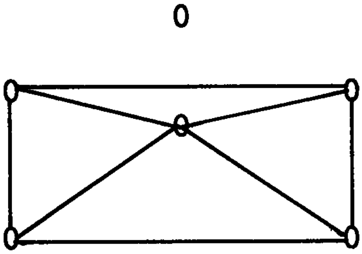
It is difficult to compute realistic cases, even highly simplified ones, from Eq. 20 without moderately elaborate computer techniques because of the interdependencies of the floor area equilibria throughout the region. One extremely simple example that can be worked out by hand and that reveals some of the behavior of the scheme is this. Imagine six villages of equal floor area scattered about a wilderness so:



These villages are virtually isolated, the transportation being just rudimentary, slow trails. Now let someone come in and build a transportation system an order of magnitude faster than the old trails, thus



If the floor area is portable, but the total amount cannot change, Eq. 20 prescribes a new equilibrium (after a suitable time) in which the center village will have become the largest while the outer villages will have decreased. The poor village at the top, left out of things, will have declined most of all. If, now the transportation network is extended,



the center village will shrink, though it will remain larger than any other, while the outer connected villages will grow. The neglected, and by now probably unfriendly, village at the top will decline still more than it already has.

It is possible to carry this further, and in a vague, qualitative way, trace the evolution of cities. A city getting started in the days before powered locomotion would most likely nucleate, according to Eq. 20, on or near a waterway—almost the only thing that could give it an access advantage. It would tend to grow in a dense fashion, because the only sites with unusually large access integrals would be those very close to already developed sites With the appearance of the railroad, operating an order of magnitude faster than anything else, places along the rail line would suddenly have very large access integrals, and new floor area would gravitate to the rail territory. If the railroads centered on the original city, and if the secular growth of floor area were great enough, the central city might also experience a growth of relative access. But now throw ubiquitous roads and automobiles into the picture, and everything changes. Access integrals everywhere increase greatly, a growth so extensive that the relative access of the center and of the rail territories almost certainly must decline. Moreover, the automobile inserts itself into the mode integral (Eq. 11), cutting off a large part of the railroads range of influence there and decreasing its absolute contribution to accessibility. New floor area, following Eq. 20, migrates to the vacant land, now much more accessible than it used to be, even though the older areas are still the most accessible. The very extensive increase in access integrals causes J in Eq. 18 to increase faster than total floor area, and the constant c grows smaller, implying a decrease in traffic between any two places whose growth in floor area is less than average. This effect expresses the redirecting of travel patterns, and tends to cause traffic on railroads, whose territories are mostly slower growing, to decline, entirely apart from mode competition.

Cities that have done most of their growing during the automobile age—Detroit and Los Angeles are excellent examples—look quite different from older cities. Presumably, this is due to persistence of history. If Eq. 20 were to start with nothing but the transportation system in the New York area and build the city from scratch, it would be most unlikely to create the central city as it now is. The processes leading to the equilibrium of Eq. 20 are slow, and to a great extent a city is what it used to be. As a matter of practical application, this does not seem too troublesome. It is easy enough, in forecasting development, to require existing floor area to stay where it is and to expect new floor area to occur in an equilibrium condition. Or, perhaps better, existing floor area can be allowed to disappear at the rate of 1 or 2 percent a year (or even at a rate appropriate to its actual age), and the amount that disappears can be treated as new space, free to seek out a new equilibrium in a new place.

In fact, this can easily enough be generalized in a working model, if one is ever produced, to allow any kind of constraints—planning, legal, physical—of a form that limits or requires development in particular locations. One output might then be a measure of the utilization that might be expected in these constrained places.

The model, in its perfected form, would produce, then, expected floor area by, say, square mile, and traffic on facilities of all modes; because of constraints, trip generation by square mile would probably also be desirable. Inputs would be existing floor area, the expected transportation system, and constraints. The floor area estimates would be generalized things, intended to let the planner understand the bounds within which to work; it would still be up to him to figure out what it would actually look like.

A most interesting possibility is that of working out some system of accounts which would set up a criterion to distinguish a better region from a worse. The model, which predicts what will happen under a given set of conditions, could then be turned around to help find those conditions that would yield a better region, in other words to plan. Also, there is no evident reason why the model cannot be applied on a national scale to worry about things like airline traffic, high speed ground traffic, and the growth of cities—the latter probably implying something about migration.

It might be mentioned that several parameters in this theory, if it may so be called, depend on large social states. The constants in the distribution function, a and b (Eq. 10), might be termed value of time and money, respectively. As a society grows wealthier, it can be presumed that b will grow smaller; as the world grows more interesting and enjoyable, and as people become less willing to spend their time in the kind of travel which, by the definition of a trip given a long way back, is in itself just a nuisance, a may very well grow larger. Also, the coefficient s of Eq. 16*b* *et seq.*, which converts floor space (or capital improvement) to trips, is perhaps not greatly different than the inverse of wealth per capita.

In summary, a few very simple ideas have been put, sometimes hammered, together in a way that seems qualitatively to explain a great many things, from the decline of commuter railroads to the opening of the West. The equations here can all be turned into real calculations, some easy, some very hard to perform (the reader is invited to guess which is which). It will take quite a few of these calculations to find out whether or not any of them are worth doing.