

TOWARDS A THEORY OF THE CITY

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By way of preface, let me engage in a little public self-therapy and recite three incidents that really lay behind some of the interests that I have developed

One of these occurred about three years ago when I was approached by a consultant for the Penn-Jersey Transportation Study. I was asked to say something about the question: if different transportation systems lead to different land use patterns, and given that we can appraise all the merits and demerits of the transportation system, but different land use patterns evolve, which would be the better land use pattern? And they were prepared to show me two land use maps, one estimated to result from one transportation plan and one from the other. I was to worry about which was the "better" land use pattern. Aside from this being a somewhat difficult question, I think what concerned me at that time was that most people who thought about this question (and I think to some extent this is only historical because lots of people no longer think of it this way) did so in terms of looking at the land use plan parcel by parcel, the game was to figure out what was the best thing to put in each parcel. Essentially, one would score plus, minus, or neutral for each parcel of land and add up all the thousands of parcels to determine which was the best pattern

What occurred to me at that time was that they really were not asking the right question. You could not look at a parcel of land and say that its use was good or not in any absolute sense; it was a question of its use relative to the use of all other parcels. A very simple notion came out of this—that one is not really concerned with the discrete description of some land use pattern, but rather with the emergence of a pattern of land use which would be more, rather than less, desirable in terms of some of its characteristics.

It is not surprising for an economist to think of this; although most of us have the concept of some kind of optimum allocation of resources, we know that that does not mean we can say how many tons of steel or how many blue shirts would appear in an optimum resource allocation. Even if we cannot really describe an optimum allocation of resources, we can say that whatever allocation of resources we observed was, in fact, optimum when certain conditions were satisfied. But, that is a very primitive kind of idea that leads one to no more than the notion that what one wants to look at is not so much a

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painting or a map or a replication of what actually exists in all of its full and rich detail, but measures of the relevant characteristics of any particular distribution in terms of its being better or worse in satisfying the conditions.

Another thing that happened to me was a remarkable conversation in Yugoslavia some months ago with a high official in the finance ministry for the Republic of Slovenia. I was told about an idea they had for a new tax; a property tax. After expressing my surprise and the general unpopularity of the property tax in the United States, I found out that it not only was going to be a property tax, but that it was going to be a very strange kind of property tax. Specifically, while there would be certain classes of property with different rates, the tax would be levied on the square meters of space without respect to its value or its location, rather than on the value of the property. My reaction was to say something like, "Oh, you must want Ljubljana to be a very dense and compact city where you will encourage high-rise construction." The reply was something like, "Well, that is all in the hands of our Ministry of Town Planning. I would not know anything about that." Then I went to visit the Ministry of Town Planning, and they showed me a very nice map with super-highways and parks and residential areas. Of them I inquired, "When you made up this plan, was this under the assumption of the present fiscal arrangement, or were you assuming the new property tax would be put into effect?" They said, "What property tax?" It showed that they are just as far ahead in planning as we are.

And so another idea occurred to me, which is related somewhat to the first, namely that describing a desirable outcome is not a very useful exercise. Drawing a map of a plan of a city the way one would like it to be is not very useful for two reasons. One is fairly obvious—simply that the drawing of this picture is not going to make it happen. Most of us understand that as one of the weaknesses of master planning. But there is perhaps a still more important weakness. This is that quite obviously one can, at least in principle, draw a plan for a city which fulfills all of the characteristics which one would like the plan to fulfill. I am sure, at least to the extent that desirable characteristics can be specified, that such a master plan can be drawn. The problem is that hundreds, if not thousands, if not tens of thousands of master plans can be drawn, all of which would have these characteristics, and all of which would be in some sense equally desirable. And so, instead of describing outcomes that one would like to see occur, one might begin to think in terms of the characteristics of these outcomes which would lead one to think that they were optimal, and then worry about the kinds of institutional conditions that would be necessary for these characteristics to be satisfied instead of worrying about exactly where various specific facilities are to be located. This is the second idea underlying my current views, namely that we should think in terms of how we can regulate institutional processes so that the actors in the locational process will somehow or other produce a location that satisfies certain characteristics.

The third event to which I allude is my recent exploration of sociology and the Burgess zonal hypothesis. In its most basic form it proposes a law about cities. It observes that they grow outward in rings, like trees. As physical deterioration progresses in an inner zone, the people who have more money move out and poorer people take over. And then the poor people take over another ring and the middle class and well-to-do move further out and this keeps proceeding in expanding rings. This struck me as a very remarkable fact, if it were true. I gather there is considerable doubt about its truth—at least in so crude a form. But the interesting thing about the literature stemming from this idea is that while it describes what cities are like and how they change over time, in very sweeping if not grandiose terms, it does not seem to have very much to say about why this process is occurring, under what conditions it would occur differently; nor does it even have much to say about whether it is desirable or undesirable. It is simply a morphological description of a changing state over time.

While I find the notion of describing cities at this level of generalization very appealing, the description itself is not really satisfactory. I want to be able to say something about the kinds of institutional or environmental conditions which generate such a process. I want to have some idea of the conditions under which this process would accelerate, decelerate, or take a different direction. Finally, I want to know something about whether it is desirable or not. In other words, I am interested in the process in the spirit of a normative economic theorist. I would like to come to grips with the city as a kind of social organization in a generalized fashion, but in a way that would produce deductive hypotheses that were testable.

THEORY OF URBAN SPATIAL FORM

By city I mean something like the Census definition of urbanized area, some compact collection of people. Throughout the rest of the discussion I will use the word city in that sense. My use of the term spatial form refers to the collection, and more particularly, to the arrangement in space of geographically identifiable activities (not necessarily economic activities) and structures associated with them. An important point of my argument will be that this sort of concept of spatial form, as applied to an urban area, needs a much more rigorous definition and analytic specification than has been applied. But, let me leave that until a bit later and for now, let me use spatial form as a loosely defined reference for such arrangements. By arrangement I mean to include the density and the spacing of things like houses, stores, factories, and transportation.

The spatial forms of the city have come to the fore as a focus of public attention in recent years. In part our concern over spatial disorder is just one of the many facets of the general perception of an urban crisis. Beyond this, however, there seem to be four more specific bases for concern. First, the spatial form itself seems to make a difference to a variety of people professionally

involved with planning and administering the city. Things like open space, wide variety of choice in locational environment, the grouping together of different kinds of people in residential areas, compatibility of abutting land uses, and so forth are seen as ends in themselves.

The second concern with spatial form would be that frequently, form affecting policies are undertaken mainly for other social objectives which impinge on the actual spatial form. In short, broad social purposes frequently underly such instruments as clearance, renewal, zoning, and code enforcement, and these purposes are not directed at a particular arrangement of things in cities, even though they have a great impact on this arrangement. This is another reason why we may be concerned with form, for we want to know what these things are doing.

Third, I think spatial form may have an influence on the effectiveness of other social processes. Let me cite a few examples. For example, public and private costs of congestion which are imposed on city occupants and production processes do vary with the spatial form of the city. Internal transportation costs certainly vary with spatial forms, especially with changes in journey to work and industrial input-output access patterns. The question of whether given political jurisdictions are sufficiently large to serve as efficient service areas for public services and to provide tax equity among jurisdictions depends upon the pattern of settlement and the demands for public services by income class, quite as much as it depends on where political boundaries are drawn.

Some people think that social conflict may be a function of the settlement pattern of socioeconomic groups; like the notion that the degree of physical segregation between racial groups may have something to do with social tension. And so we might be interested in whether elements of the physical plan *per se* contributes to such segregation.

A fourth reason for being concerned with spatial form is that a greater ability to predict it, either historically, or as a function of public policy, probably will be very helpful to urban planning and administrative decision-making.

Thus it would seem that there is a need to develop an operating theory of the spatial form of the city in a manner which is empirically testable, to develop operational definitions for the variables in it, to collect relevant data, and to test hypotheses contained in the theory

The foregoing remarks imply that conceiving a theory of the city is a useful methodological position. What I mean by this is a theory of the city as a meaningful social aggregation in the same sense that we recognize a theory of the firm, the household, the family, or the individual consumer. To construct such a theory, a function or functions of the city as a city must be postulated, and hypotheses constructed with respect to how those forces which most affect the city's fulfilling of these functions influence the characteristics of the city and its evolution. Attempts must be made to validate these hypotheses and to evaluate the relative social desirability of outcomes.

It should be pointed out that a theory of the city is not meant to imply a set

of propositions that will analyze and determine all those kinds of human behavior and their relationship to environment which are found in cities as opposed to non-cities. A general theory of social science in urban microcosm is not what is intended. Instead, I think I really am intending an examination of selected functions of a particular institution which I call the city, and the aspects of social behavior most closely connected with those functions. Not only is the city an institution which many people view as behaving very poorly, but also it is one which has not been studied in a systematic *a priori* theoretical way. I do not mean to say, of course, that no one has studied cities before. But I think there has been relatively little study of the city as a meaningful aggregation in an *a priori* deductive way which leads to some sort of testable hypotheses about it. Also let me note that I am not talking about urban economics. For example, we can talk about economics as a discipline which is concerned with the behavior of certain units that we call households and firms, and urban economics as the study of how these kinds of units function in an urban setting. Instead of an urban economics we might be talking about an eco-urbanomics as the study of an institution called the city. It is not about things in the city—it is about the city itself. And one could study eco-urbanomics or socio-urbanomics or politico-urbanomics. One would not have to study everything about the city at one time. One might concentrate on the economic or the political or the sociological aspects.

I would like to emphasize that the intention is an applied theoretical approach to the city *qua* city, as an institution. Much of what is done now under the heading of urban and regional studies deals with problems in the city, rather than of the city. Let me give a simple example. The problem of adequate employment opportunities is a function, in any particular city, of the product demand, the determinants of which may be largely external to the city, worker productivity, and the functioning of the labor market. These will determine the level and distribution of employment in a city. That regional differences exist, with the function of space affecting the solutions, certainly is the case, so that research on such problems in a regional or urban context is a very important contribution. But such research ordinarily focuses on particular institutions or groups within the urban area, like firms or industries, consumers, the labor force, or particular local governmental units. It ordinarily does not focus on the urban area itself as a meaningful analytic aggregate. This may be unfortunate for a number of reasons.

First, institutions and processes may be affected by the kind of city in which they are located. Second, the form of the city itself may be highly dependent on the working out of social, economic, and political processes within it. Third, there seems to be considerable sentiment to the effect that cities may be functioning poorly, aside from whether the institutions within them are functioning well or not. Even where particular institutions are functioning poorly, it seems useful to investigate the possibility that there is something in the functioning of the city itself which produces breakdown in these processes

within it. The other side of the picture is the investigation of the extent to which the city takes its form from its environment and the particular process within it. It is this question, at least initially, which mainly concerns us here.

DETERMINANTS OF URBAN FORM

In regard to the theory of determinants of spatial form of the city, two problems arise at the start. First, the city, as I have defined it, probably is not a decision unit to any important extent. Second, the form of the city probably influences virtually every kind of human interaction. Insofar as the first question is concerned, it does not seem very serious. Industries, neighborhoods, occupations, and races are not decision units either, yet we still find that many processes can be analyzed usefully by interpreting such groups as if they were organic units; that is, as if they were engaged in some kind of purposeful behavior in a functionally identifiable way. As to the city influencing in some way every aspect of human behavior, the situation simply would have to be compromised. This is a familiar aspect of almost all social science methodology. A business enterprise is a very complex organization, affecting the lives of the people in it in myriad ways. Nonetheless, it still seems useful, for some purposes, to study businesses as if they were involved only in the transformation of resources into commodities.

With these limitations in mind it might seem reasonable to regard the city as the unit within which the following functions are performed. As noted above, we have to specify some functions which uniquely are those of the city:

1. The selection of enclosures for all of those activities which locate in the city—that is, which cluster around nodes, in continuous areas of markedly higher density than is found in the non-city. This would include residential, production, social, governmental, and cultural activities. It would involve understanding the emergence of particular classes of structural forms out of the much wider range of technically possible problems or solutions. Some sort of selection within these possibilities emerges; selections of tall versus short, dense versus sparse, durable versus nondurable, high versus low quality. These selections do not really emerge out of the real estate market—they emerge out of something which I think is substantially larger than the real estate market, and I find it useful to regard this whole complex of processes out of which they emerge as “*the city*.”

2. The arrangement of these facilities and enclosures in a way that will facilitate those interactions between units (that is, firms, houses, enterprises, organizations) which are the basis for their being in the city as opposed to the non-city. This would include the arrangement of facilities designed to facilitate the interactions themselves, that is, transportation and communication.

3. To serve as the environment in which a number of services are consumed and paid for, or resources created in common or semi-common by the inhabitants and institutions as well as by individuals, or some identifiable

group of them. Obviously this would include government services as things consumed and paid for in common. But it also should include such things as higher education, medical and health services, cultural and recreational services, clean air, clean water, a many-skilled adaptable labor force; in short, a variety of things which are produced by an urban environment that cannot be said to be produced by the local government in any sense, or by firms or by households, but by the urban environment.

What we really want to develop is some kind of theoretical framework within which we identify factors which are determinants of city form and which, in turn, produce some spatial form in an analytically predictable way. Then we search for some method of evaluating the resultant spatial performance, which, in turn, probably would feed back upon the determinants of spatial form themselves.

The research needed for such a theory should be directed to the following three problems:

1. Elucidation of a deductive theory of the determinants of the spatial form of the city.
2. Specification (definition and measurement) of the spatial form of the city in a way that would make testing of the theoretical hypotheses possible.
3. Development of methods for evaluating the effect of the spatial form of the city on the performance of the city and the social processes within it.

The number of things that might affect the spatial form of the city certainly are quite large: there should be no attempt to maximize the number of testable hypotheses that can be formulated. Instead, hypotheses should be formulated only with respect to a limited number of *a priori* selected determinants. The selection of these determinants should be guided by three principles: (a) that there be a strong *a priori* basis for suspecting a strong influence on city form, (b) that they represent forces, or be importantly related to forces subject to public policy control, and (c) that they represent areas within the competence of the researchers.

Given these principles, the primary factors an economist might select as determinants of city form might be:

1. The intra-area transportation systems. This would include consideration of all modes and several characteristics of them, such as, speed, cost, pricing, and frequency.
2. The system for providing public goods by local government. This would include the system(s) of taxation employed, the kinds of public services provided and the effects of having separate small jurisdictions within which taxation and expenditure are carried out.

Other important factors which might be considered in the same framework, if we had the knowledge of them, are the following:

1. Limitations in construction technology or urban design possibilities.

2. Personal desires for "social distance," *i.e.*, the desire of individuals, *ceteris paribus* to live near people who are similar to them in socioeconomic characteristics.

3. The importance of living in proximity to others in the same occupation or employed by the same establishment.

One constraint imposed on this aspect of the research probably should be noted explicitly, namely, that if the attempt is to develop testable hypotheses, the asserted determinants of city form would have to be expressed in ways in which they could be observed and measured, at least in principle, and to a considerable extent in practice. For the most part, however, what is called for is quantitative characterization of the kinds of things which social scientists are used to dealing with in this manner. The most difficult item, perhaps, is the transportation system. But recent work suggests that this problem is manageable.

If the problems of definition, specification, and measurement are minor annoyances in expressing the determinants of city form, they represent a major research problem so far as specifying the spatial form of the city itself is concerned.

Part of the problem, of course, is the lack of consistent data on land use. But there seems to be involved a much more fundamental issue which arises out of viewing the form of the city as a functional element within an organized theory. In this context, spatial form does not mean a detailed description of every physical form and every spacing between forms and people. First, assembling and classifying such information would be a very formidable task. Second, spatial form probably could not be predicted in anything approaching this extreme degree of disaggregation. Third, even if it could be predicted at this scale it does not seem likely that we could discriminate between the relative desirability for the urban society as a whole of most of the different possible patterns at this scale of observation.

Therefore, it would seem that the description of spatial form must be condensed in detail, to be meaningful as well as manageable. But more than that, it must be written in an analytical form as a variable or set of variables which take on continuous or discrete values if ever relationships between people, institutions, and the emergent spatial form are to be tested.

In short, a land-use map is not a number and cannot be fitted into a quantitative model. That it is not a number is not really important—it could be described as a very large set of numbers. That it is a description of an outcome and not the properties or conditions of that outcome is the real problem.

This latter point perhaps can be understood more easily if the problem is viewed in a more familiar context, namely the problem in economics of determining optimum resource allocation. There we want not a description of the actual resource allocation (a detailed list of inputs and what was produced), but evidence that certain conditions have been satisfied (competitive pricing, production at minimum average cost, and so forth) which if satisfied, would

cause us to conclude that the resultant allocation was in fact optimal. We resort to this kind of methodology for two reasons: (a) there is reason to believe that there are many discrete solutions which would be optimal, and hence desirable on economic grounds; (b) we want to engage in the analysis of public policy aimed at correcting non-optimal situations as well as simply evaluating specific outcomes *ex post facto*, and hence seek for theoretical explanations relating outcomes to controllable and uncontrollable elements in the environment. The idea here is that this same methodological view could be applied to the size and spatial form of the city. In this case too, a large number of specific outcomes probably would be satisfactory, even if a large number of considerations, non-economic as well as economic, were taken into account. What finally is being sought is the specification of a set of conditions, which if satisfied, would lead us to conclude that the resultant spatial form was optimal with respect to one or more processes of, or in, the city, depending on the degree of generality of the model.

CONCLUSION

The foregoing has provided two criteria for the specification of characteristics of spatial form: (a) that they be relevant to the effective performance of the city, and (b) that they be predictable (explainable) from the determinants of city form being considered. In the context of this proposal this means that we would be looking for those characteristics of spatial form which are influenced importantly by the transportation system, the local taxing and public expenditure institutions, and other factors considered, and which are relevant to the economic efficiency of the land use-transportation-public services pattern of the urban area.

Obviously, the measures initially selected would be subject to considerable revision as the theoretical effects progressed, and certainly after empirical testing. Some thought has gone into this question and the following can be given as illustrative of the kinds of measures which could be used, at least initially: population, area, density gradient, socioeconomic gradients, heterogeneity, average height, height variance and gradient, average spacing, spacing gradient, concentricity, sectorality, transport conformity, and political boundary conformity. Most of these measures are self-explanatory. Some that may not be are as follows.

Heterogeneity. The average size (absolute and as a percent of urban area) of all single contiguous land-use areas under some standard land-use classification.

Concentricity. The extent to which concentric rings (in distance or time, adjusted for topography) could be drawn about a central point such that they would tend to segregate people of various socioeconomic classes and different land uses. Analysis of variance techniques could be used to establish such measures.

Sectorality. Essentially the same concept as concentricity, but with respect to radial segments.

Transport conformity. The extent to which land use conforms to what would be predicted from a given transportation system and the assumption of transport cost minimization as the only factor affecting location.

Political boundary conformity. The extent to which political boundaries define patterns of settlement in terms of socioeconomic characteristics of land use. Perhaps this could be measured by the ratio of the average variance in heterogeneity with jurisdictions to the variance in heterogeneity between regions.

A major focus in this part of the research should be on the evaluation of spatial results, as opposed to their prediction. This is in contrast to most past and current work on analytical models of land use. The evaluation techniques to be developed should permit a more effective and general analysis of the interactions between costs of access, congestion, and construction. In addition they should permit an analysis of intra-urban variations in tax yields and public expenditure requirements on the basis of subareal units not necessarily coinciding with political boundaries. To meet these evaluation needs, however, the models will have to be transport cost intransitive with distance in order to represent real land use patterns in them. (They must allow for cost of movement from B to A to exceed the cost from C to A even where B is closer in miles to A than is C.) Topological problems enter when more than one chain of dominant paths exist (in the foregoing, suppose a location D, which is closer to A than B, but further than C).

In conclusion, I think it is possible to begin thinking of urban form in a generalized way. I hope that when interpreted correctly, I will be seen not as looking for a theory of a generalized concern with urban man, but rather for a generalized and generalizable way of looking at particular processes and particular concerns of (not in) the city

COMMENTS

STEVE PUTMAN, *CONSAD Research Corporation*

I have the feeling that we are not admitting that even before models existed, decision-makers were asking those who knew a little bit about computers and a little bit about statistics and a little bit about economics to help them decide what actions should be taken if they had the opportunity, in their city, to change things that were unpleasant or inefficient. And I think that this jack-of-all-trades probably discovered on investigation that the questions were almost impossible to answer. He then tried to throw the policy-maker off

guard by asking him some new questions. After that he gathered together colleagues to answer these new questions which had been asked.

I think this sort of thing has been going on here; we tend to discuss criteria for evaluating the results of transportation plans and land use plans without making sure that we have valid ways of forecasting the things that we later plan to evaluate. What bothers me particularly is the nature of the constraints on goal formulation. For example, the first thing that I considered when I began modeling was that within a city we were constrained to consider only things within a politically defined city boundary, and further defined by aerial units which were also politically defined and by census tracts. Thus we were confined to working on a very specific level. We talked of why firms were moving from one place to another. We talked about households disliking other kinds of households, and how they would not locate in census tracts where these others lived.

After doing this for a couple of years, I found myself in the position of working with a huge region several hundred miles long, also politically defined, where data about firms locating in counties indicated that their behavior was very different from that of firms locating in census tracts. The study of household location in terms of prejudice became irrelevant.

This experience suggests the question. how do we tie together the previous discussion with some of the kinds of very general questions that Charlie Leven posed? If we stop to think about a city and certain ways of describing "city phenomena," where does this leave us with respect to the questions of movers? Similarly, if we talk about the questions of movers, I am concerned as to how this relates back to questions of city-wide phenomena. In this regard, I think that there have been studies in which we tried to go from looking at micro decision units, to seeing what the whole city would be like. I am not sure that it is relevant to discuss the method by which we move from individual behavior to a theory of the behavior of groups. Nor am I sure that we should; but I think that what I would like to consider is whether there are, in fact, city-wide or region-wide phenomena, and whether these phenomena are caused by aggregations of movement? But these would be derived in the way that Hooke's law of pressure, volume and temperature of gasses was derived in the absence of information concerning Shroedinger's wave equation and other kinds of atomic and molecular physics. I think that we probably could consider descriptions of regional and city-wide phenomena, but in the same way that atomic and molecular physics have in some way contributed to understanding why Hooke's law works or ways in which it might not be relevant. We can look at individual decision units or firms in terms of how this might give us information about our urban or our city-wide and regional phenomena, without expecting information that we could directly aggregate.

DANIEL BRAND, *Peat, Marwick, Livingston & Company*

Charles Leven has presented a most stimulating paper. He has thoughtfully

commented on and suggested directions to the efforts of many land use modelers around the country, including our own efforts in Boston over the last four years. I am almost surprised at how closely his approach to modeling spatial form resembles our own, since we approach the problem from quite different institutional bases. This closeness would indicate that either we must be close to cracking the problem (or we are all wrong) or that the organizers of this Conference have done a fine job of bringing together preachers of the same gospel to stroke one another.

My comments are in two parts. First are comments and thoughts on specific points raised in the paper. Second, is a description of our work in developing land use models in Boston. In many ways our experience with *EMPIRIC* represents a case study in the approach on which Mr. Leven and many of us seem to agree, and so a brief discussion of the results of this experience are appropriate here

There are certain almost definitional points on which I agree fully. We should not be concerned with land use, as in land areas, but in "the arrangement in space of geographically identifiable activities." We need to examine selected functions of the city "in an *a priori* deductive way which leads to some sort of testable hypotheses about it." We may find it useful to treat activities such as "industries, neighborhoods, occupations and races" as though they were decision units, even though they do not normally engage in some sort of "purposeful behavior" in the context of location (with the possible exception of the last named example).

Also we have some similarities in purpose. Leven is "interested in the (urban spatial) process in the spirit of someone interested in normative economic theory." I could not agree more. It can be frustrating to argue with colleagues who refuse to see that you have to be able to evaluate and then push the right kinds of programs or expenditures of public capital in transportation, relief of poverty, educational and social services, etc. Some people are only concerned with and get hung up in the process of change itself: the political scientist in problems of how to change political organizations, the sociologist in changing existing group structures, and the land use planner who says this part of the region will not grow (or decline) the way your model says it will, because these people do not want change. It is often very difficult to get across the idea that a comprehensive approach may first be needed in order to evaluate what programs and resultant changes may be good or bad, before struggling with the problem of change itself.

Leven also states that a major focus of our research efforts in land use modeling "should be on the evaluation of spatial results, as opposed to their prediction." The two purposes are, of course, complementary if we can formulate a model of urban change which uses and/or predicts measures "relevant to the effective performance of the city" and which predicts "from the determinants of city form being considered." An example of the comple-

mentarity of evaluation and prediction is our desire to use a model such as the Boston EMPIRIC Model, to predict certain activity distribution patterns which might be considered "optimum when certain conditions were satisfied." EMPIRIC is a linear model and so can be formulated as a linear program to do this. With such a procedure we do not have to draw pretty pictures of master plans, all of which are pretty, etc. This kind of complementarity leads us to the conclusion that we should model the urban spatial change process using variables and measures which allow us to consider optimality in terms of the kinds of decisions which we are called upon to recommend or make in the expenditures of public capital.

The second part of my comments relate to the EMPIRIC land use model work we have done in Boston over the last four years. The first purpose of developing the EMPIRIC model was to forecast and evaluate the future land uses which would occur in the Boston region given the proposed alternative transportation and other public facilities plans. The second was to understand the urban mechanism. The client was most interested, of course, in the first use of the model. We were probably more interested in the second. You may notice that these are the first two of Charles Zwick's three purposes of land use models. Indeed, in Boston we also may be achieving the third purpose, that is, using the model as an educational and propaganda tool, whether we like it or not, in order to get the plan implemented.

The EMPIRIC model is an aggregative level model in Chapin's terms. I agree that as we go from the micro to the more aggregative level we will see the same basic market factors in effect, and we will see the same parameters descriptive of the aggregative process as of the micro process. Also, we will see different subpopulations exhibiting different behavior. In formulating EMPIRIC, I feel we stuck fairly well by Leven's guidelines with respect to (a) not maximizing the number of testable hypotheses, (b) including suspected *a priori* influences on city form, and (c) (particularly) that we select determinants within our competence. With respect to the latter, I feel we do know something about transportation.

The EMPIRIC model rests on the following hypothesis: The change in activity in a subregion over time is a function of the changes in other activities in the subregion; the levels of the activities in the subregion, the present and future accessibilities to other activities, singly or collectively; the land available in the subregion for development, and the present and future quality of such public services as water supply, sewage disposal, and schools. The particular model calibrated in Boston distributed four classes of population by income groupings, and five classes of employment. The form of the model lends itself also to stratifying population by race, educational level, or other characteristics. We picked these population and employment output variables after an analysis of the data for Boston, and especially according to the wishes of the client for output data. The model was to be used primarily for input to traffic forecasting techniques. Later, we discovered a wealth of output data

that could be used for housing, solid waste disposal, open space studies, and other analyses.

Some interesting results on locational theories have come out of this work. A short description of some of the theories and hypotheses that were verified in this work may be in order. The estimated equations making up the model indicate that the accessibility variables are the most important of the policy variables for forecasting the locations of population and employment. However, the non-policy variables over which the planner has no direct control are generally stronger determinants of locational patterns than are the policy variables, in particular, growth in the various population income groups. The social distance measure which Leven has postulated enters here. Also, among the strongest variables in the employment equations are one or more of the other output variables. This provides evidence of the realism of using a simultaneous model such as EMPIRIC.

In all the equations one of the most important determinants of growth was the lagged variables, that is, the value of the output variable at the beginning of the forecasting interval. In every instance but one, the lagged variable carried a medium or large negative sign. This indicates the concern with space, the fact that people are tending, all else being equal, to locate at lower densities. The single exception is very important in that it is for the lowest-income population group. In only that instance does the presence of the same activity at the beginning of the time interval induce increased growth in its own share of the activity. This is striking statistical evidence of the increasing growth of low-income ghettos, about which there is much discussion today.

Many of the other coefficients express relationships which are worthy of mention. In the low-income population equations, vehicle accessibility is such as to indicate that low-income families do not have the resources to take their full share of the advantages of improvements in the regional highway system. This is in line with Stowers' comment about shorter moves in the lower-income groups. However, the highest-income group exhibits the same behavior with respect to accessibility. This would indicate that they chose to pay increased transportation costs relative to the other groups to enjoy certain residential amenities and a concern for space. The middle-income groups, on the other hand, exhibit the concern for improved highways with which we are all familiar, indicating a desire to increase their accessibility to other activities.

In conclusion, there is a debate going on between the purists, and the applications or task-oriented people in planning (to be polemic). I think Leven states the process of model-building in a way with which I can entirely agree when he calls for producing hypotheses which are testable with respect to forces effecting urban change and effective measures of urban form. Empirical tests are required because the problem is so complex. Only through the use of both techniques, hypothesis building and empirical testing, will we be able to develop methods that will adequately forecast the distribution of large numbers of variables in order that follow-up steps in the planning process can proceed.