CONSTRUCTION OF MODELS

The fifth and eighth sessions of the Conference were given to discussion of issues in model-building. No formal papers were presented at these sessions. At the fifth session panelists Kenneth Schlager, Britton Harris, T R. Lakshmanan, and Boris Pushkarev opened the discussion. At the eighth session Britton Harris, as session chairman, opened and moderated the discussion

Discussion touched on many concerns that ran through the conference These ranged from concerns with the data base for modeling, particularly the appropriateness for model-building of existing approaches to stratification and and classification of data, and concerns about aggregation of data in models, to questions of the relative importance in terms of resource allocation that should be assigned to different modeling strategies. The discussion from both sessions is summarized here. Where possible, selected direct comments of the discussants are used to present the major topics and viewpoints.

KENNETH SCHLAGER, *Southeastern Wisconsin Regional Planning Commission*

The topic of this session is model-building. Discussion will be general, taking its start from optimizing and design models as related both to decision-making and to the functioning of the urban environment. I think at least a good part of this discussion should be devoted to the subject of design models, which I would define as models that are used to determine design objectives and criteria, costs and various constraints—providing a search procedure for coming up with a recommended spatial plan. We will be interested, I think, in considering the question: What are the applications of such models in the planning process? What is the present state of the art? What are some of the research needs?

What is the present allocation of resources to design models, or normative models as opposed to predictive models? I feel strongly that the allocation is very distorted. How many of these problems are really design or normative problems?

Two extremes of conditions might exist: one in which many well thought out, intensely designed plans would be ready for implementation, but could not be implemented; in which case there would be very little need for design models. The other extreme would be the case in which implementation was possible, but no good recommendations existed. Here the emphasis would definitely call for design models. Of course, we are somewhere in between, but I

do believe there is a certain amount of misallocation of resources in this area. I agree with the idea that a theory of the city is a good thing, but in terms of the immediate problems of designing plans and implementing plans, it might be well for us to look at the role of design models.

To begin, I would like to present some of the needs that we have seen in our work in design models in Southeastern Wisconsin. One is in the area of cost data. Almost any design model involves measuring the cost of alternatives, and the work that has been done in the area of detailed costing has been very slight. We have done much, I think, in a short time, but it is not adequate for the long haul. Another important need is an ability to translate subjective goals into design criteria. A third area is the model as such which does not try to copy a process in real life, but is rather an efficient search procedure for evaluating many alternatives. A fourth area which we found to be quite important in terms of the user is the man/machine relationship. What is the relationship between the person who runs the model and uses the model, and the model itself? We are beginning to feel that the planner, rather than a systems analyst or programmer or data processing expert, should be able to work directly with the model. In other words, the design model is more like a laboratory experiment than it is a data-processing exercise.

Another area of discussion should be the urban design process itself. Our previous discussions have been on the urban development process. We have tried to understand how and why cities develop in certain ways and how they may develop in the future, but there has been little discussion of the design process, of how our plans develop, and of how models might influence this process.

We might also discuss the design qualifications of people now in the model-building field. Perhaps one reason for the slight emphasis in this area is that the background of people working in urban model development has oriented them towards models that describe and predict the world rather than towards design interests. I think it is difficult to conceive a design model if the model-builder has never been involved with design.

In summary, I would like to make some comments about our own design work in southeastern Wisconsin. In July 1966, we received a grant from the Department of Housing and Urban Development for the development of a land use plan design model. The objective was to have a three-phased program in which the first phase would be to build the model and make it run. The second phase, which we are just starting now, would be to apply this model at community and regional levels in order to come up with an actual plan that we could compare with the plan that we had developed with a variety of quantitative aids, but mostly intuitively, in the region before. In the third stage, we would use our experience to write manuals and training aids so that people hopefully could use this in other areas.

A couple of years ago, one of the articles in Britton Harris' series in the *Journal of the American Institute of Planners* described an approach using

linear programming, which for several reasons, we found to be very inadequate as a means of handling a plan design. One reason was the discrete nature of design planning. A design modeler is interested in the locations of hospitals, schools, residential areas, shopping centers. A linear programming model used to deal with quantities did not seem a very appropriate way to handle the problem. Another problem was that many of the important costs were not just the location costs, but linkages that had to be developed. An area developed on very nice land might require highway, sewer, and water facilities that had to be built new or had to be extended. Consequently, we worked out a modification not of the program's objective, but of the method. We changed the linear programming model from using variables that represented areas of land to an approach in which we could define certain basic modules such as schools, shopping centers, and residential areas, knowing full well that some of the initial definitions of the modules were arbitrary. These modules could then be the elements of the design model.

Our orientation was at the community and regional levels rather than at the neighborhood level, and so we defined a set of 70 or 80 modules. The purpose of the model was to locate these modules in spaces which we defined as cells These cells were just geometrically irregular areas of land.

We also had to incorporate the cost of development into the model. We developed this as much as possible from the elemental cost data of digging trenches, putting in pipe, and building roads. These costs were an important input to the model because in going through alternative solutions, the model would evaluate what the cost would be of putting a module on a particular type of topographic area, and also the cost of linking it to other areas that would be in different cells in the planning area.

We also put into the model various types of design constraints geared to prevent certain undesirable plans from being implemented. The best background help that we had in the conceptual area was the work that is going on in electronic packaging design. We found the idea of dividing sets and hill climbing very applicable, because it enabled us to deal with these discrete things through a partitioning process.

Up to the present we have made a preliminary application of the model to Germantown, Wisconsin, for which we took our forecast for 1970 and 1980, translated this into a number of modules of various types, and went through an exercise of running it We did not make any attempt to make this realistic in the sense that our goals or constraints resemble those of this town, because we were only interested in exercising the model and testing it out to see what problems we had. In the second phase, however, we are actually going to use our goals, our design standards, and constraints in southeastern Wisconsin; we are going to use the resource inventory that we have, which is, of course, very critical in terms of soil and topography, and we plan to apply it to regional development planning in this area. This is an example of a design model and I

described it to provide a little background as to what a design model does, so that we are not just talking about vague ideas.

BRITTON HARRIS, *Department of City and Regional Planning, University of Pennsylvania*

I think we are dealing at this point with a very interesting and somewhat difficult question, and the ideas which I have are rather tentative. I would like to refer, however, to two things which were said previously. John Hamburg said with some passion that a model-builder must be a good deal more than a model-builder. I am not always sure exactly what that remark means, but I think that in this case he was referring to a somewhat larger context than the one in which model-makers are operating, which is planning and problem solving

I think that the distinction between descriptive models, predictive models, and design models is a useful way to approach this problem of the differences between planning and problem solving on the one hand and building projective or predictive models on the other. This is a problem which has been subterranean. Throughout the conference it has come up to the surface and if we do not recognize it explicitly, I think it will create a good many problems.

I also would like to refer to Leven's talk which brought to the conference an economic and optimizing approach which, in my opinion, is extremely useful. However, I would like to discuss an aspect of this approach which has not yet been mentioned In urban development, as we describe it in predictive models or attempt to deal with it in design models, there exists an important feature which we call externality which does not exist in the same way in national economic planning. Externalities take the form that certain types of land uses, for example, are either mutually supporting or mutually repelling. These externalities lead to economies of scale and economies of agglomeration, and they have extremely important consequences for analysis and for model-building What they say essentially is that there is not any single optimum. Externalities indicate a situation in which there are local optima in any particular setup of policy; one may achieve a local optimum, but that may not be at a very good optimum. Let me give you a concrete example, based on Leven's discussion of the size of the city and on his discussion of the way in which cities are formed and grow.

If we assume that metropolitan growth is largely determined by individual locators' decisions and if some locators require to be located in moderate to large-sized subcenters, then an interesting situation may develop. If a growing city has only one large center, we may get urban sprawl and large subcenters may never develop. If, on the other hand, through some accident large-scale subcenters exist, they may continue to grow. Optimizing behavior might thus lead to different outcomes and the desirability or optimality of these outcomes might also differ.

This problem might be resolved in the future by a conscious policy of de-

veloping large scale subcenters. After all, Nassau and Suffolk counties in New York are now as large at least as the Twin Cities standard metropolitan statistical area, and they could support as much symphony music, as many art galleries, as many public recreational facilities as the Twin Cities, were it not for the powerful pull of Manhattan. I am raising these problems to emphasize the fact that optimum seeking methods will not necessarily create a large metropolitan subcenter in Nassau County. This becomes, then, a problem of planning and of design in the larger sense. I think that as model-builders, whatever our predilection, we must be very conscious of this particular problem and of the technical differences between prediction and design. I would like to treat this problem, and the problems associated with it, in terms partly of some of the work which we are doing at the University of Pennsylvania on the development of the Herbert-Stevens model which is based on the Alonso theory of urban land rent, and by extension, of housing rent. I think the application which we are attempting to make illustrates very clearly some of the overlaps and differences between design and prediction, and some of the problems of setting up a design model.

The model which we are working on is certainly an optimizing model, but in the behavioral rather than the design sense. I have spoken briefly about our difficulties and tentative conclusions in developing preference functions, and our capability of estimating what various groups in the population will be willing to spend for rent for facilities of different types in different locations. We found that there is a marked difference between population groups and the way in which they view the housing market. These differences depend on family size and income (factors which Herbert and Stevens take for granted), and they must be subjected to study if we are serious about putting in new features and new technologies in the economy and in the urban arrangement.

Now, assuming that these preference functions exist and have been identified, our model takes as inputs a designed location of employment, except possibly for retail trade employment, and a designed transportation system, which together enable us to establish levels of accessibility. Zoning restrictions and design standards can also be incorporated into the model. The model, then, locates population by a linear programming algorithm either in the existing housing stock or in new construction which is necessary to accommodate the additional households. This may be done for the population as a whole, or it may be done for increments of population, making it into a more dynamic type of model. Cost information is very important; design standards are very important, and we expect them to influence the functioning of the model.

There are two or three major observations that I would like to make about the way in which this model relates to prediction and to design. In the first place, in spite of the fact that it is an optimizing model, it is not a normative model unless you choose to interpret it that way. It achieves a Pareto optimum in location and can be interpreted as assuming that people behave in an optimizing way when they locate in a particular place. Insofar as people do not

behave in an optimizing way, it can be said that this illustrates the achievable optimum in location, given the inputs and provided that people had perfect information and were free to move and to relocate. Interpreted in this way it sets the highest level of satisfaction which might be achieved. This knowledge is important because we are dealing with utilities and preferences, and we are able, in some degree, to measure consumer satisfaction. This measurement, however, will always be the same for a given run of the model, that is, for given inputs, so that the design aspects are outside of the model. This is why I said that the model itself is not normative.

The design aspects take two different forms. Constraints such as zoning can be imposed on the model which will force people to locate in prescribed patterns, regardless of the satisfactions which they would achieve. Through an interpretation of the dual variables of the model or through iterating the model in a special way, it is possible to estimate the value to the user of the housing which is attained under these different sets of constraints. One can play with the large scale inputs such as the location of employment or the location of transportation routes and one could play equally well in regard to housing technology, with the cost of providing housing of different types. Thus, for different planned arrangements, one could achieve measures of utility for locating population, and in this sense the model can be considered evaluative.

In general, I think that there are many desirable features connected with models which have the design characteristics which Schlager has talked about and which, to a certain extent, I have talked about. Even within the large-scale design of transportation routes and employment location, our model can be considered a design model, in the sense that it designs the densities, the subdivision regulations, or the zoning regulations which will apply over the metropolitan area if you wish to achieve optimum location. In the future, the optimum locations may be quite different from present ones and in this sense the model is exercising a design power, if the implementing agencies are prepared to enforce a kind of zoning which would be desired at a future date. The model, for example, could indicate that in a growing metropolitan area the densities which would be predicted for 20 years from now would be higher than the ones that would be predicted for the next year. In this case there is a design decision to be made which is outside of the general predictive framework. A choice must be made as to whether, in this case, we propose to accommodate next year's locators at the densities that they would like, or to force them to locate at densities which the people, 10, 20 or 30 years from now would desire. This raises a whole host of planning problems, but permits us to examine them concretely and explicitly.

Finally, I think that two or three features of optimizing models need to be examined carefully. Optimizing models are efficient for answering many economic questions which people have urged us to consider. And I think it is quite possible that models which have strong equilibrium implications may tend to control errors of projection, virtually by way of negative feedback. If

things get out of line in a projection, the equilibrium aspects tend to kick them back into line.

However, there are two dangers that I would like to emphasize. One is that if we use backward seeking models, we have to be very careful about the objective functions which we use and their social implications. Now, I think there may be a danger in Schlager's work in that he emphasizes the minimization of construction costs without adequate attention to user costs and satisfaction.

The question is, does this type of design model represent a complete cost benefit analysis, and if it does not, how do we get one? Another aspect of the same problem is that the objective functions which the economists put into their models frequently do not deal with social costs which must be considered if we wish to optimize in the social sense. Let me give you a simple example. Location at very low densities may cause undesirable results. In England, for instance, low-density location might use up the landscape which is highly desired. In the United States we have a little bit more landscape to go around, but it might raise facility costs very substantially, and these social costs may not be accounted for in the cost figures for the individual household. We could deal with this discrepancy either by putting the actual costs into the model or by postulating restraints and not allowing densities to fall below a certain level. Since the ultimate purpose of planning is to improve conditions, optimizing models fill an obvious purpose. In spite of the many difficulties which I have identified, I agree with Schlager that much more emphasis must continue to be placed on backward-seeking optimizing design models.

T. R. LAKSHMANAN, *CONSAD Research Corporation*

I believe that the objective of this Conference is to identify promising lines of inquiry and a broad outline of a "plan for innovation" in the area of urban development models. I shall attempt accordingly to structure my brief comments by these objectives. Essentially, my comments pertain to three areas: the range of public policy issues relevant to urban models, the approaches to model design, and strategies of innovation.

Discussions on model design appropriately begin with questions of scope of the models. What processes are to be described by the models? What range of public policies should these models be concerned with? The greater part of this group, I daresay, has been concerned with the description of urban growth processes as seen from the perspective of land use and transportation planning. This has meant traditionally a focus on physical planning policies pertaining to land development densities, transportation utilities and the like.

There has developed recently, as evidenced in the earlier sessions of this Conference, a clamor for enlarging the scope of the models to include a variety of social issues such as manpower training, poverty programs and other related social issues. This demand for scope extension of the urban development models from new model clients expresses a recognition of the interrelatedness

of physical and social planning policies and a desire to build on the only major effort in modeling of small area processes and changes. Predictably, model-builders in the land use and transportation studies, keenly aware of the complexity and the resistance to easy abstractions of the metropolitan phenomena, remain skeptical of these "psychedelic" approaches to model scope definition.

However, it seems to me that urban development models should be cognizant of these new clients and focus on physical and social planning processes and relevant policies. Our recommendations for future urban model development strategy should reflect this broadening scope.

Another question concerns the nature of modeling strategies themselves. Discussion of this subject should begin with a partial definition of models. I view models as ways of portraying functional relationships between a set of control or policy variables and effect or consequence variables. The choice of control (or policy) variables depends upon the scope of the issues under consideration. As the issue space enlarges, so do the control variables.

What, then, are the relevant effects or consequences associated with these control variables? These effects or consequences of interest should be described by their magnitude and several dimensions of incidence of such consequences. Thus as we are concerned with transportation, land use, integration and other social policies, our models should measure the magnitude effects of the relevant policies in the first instance In addition, the models should describe these impacts in terms of incidence. In other words, who receives the effects? Which population group? Which economic sector? Which geographical area? What points in time? What do these requirements imply for model-design strategy? The design of a model is often a trade-off among such factors as the diversity of control variables to be considered, the diversity of the impacts, the state of the art, and the information base available.

The models designed and built by such trade-offs are judged by both the model-builders themselves and the public at large. Peer-group (modelers) judgments are based on such criteria as the relevance of the model to the problem under attack, validity, and experimental utility Judgments by model clients may be based on the comprehensibility of model processes and results, or on policy coverage, or the degree to which the model reflects public concerns—the quality of its treatment of policy variables and the quality of those variables themselves. The urban development models do not do well by these criteria.

Those of us who have worked on urban development models know that such criteria as parsimony and accuracy in model construction are hard to meet currently; perhaps a more realistic criterion of the model "goodness" is the insight gained into the development process.

Another aspect in model design discussions pertains to questions of design versus impact models. In impact modeling, one estimates consequences; but design models go beyond impact models in specifying a criterion function by

which to select among the consequences of alternative plans. This criterion is basically a social-welfare function, in which the weights attached to various impact vectors represent some sort of a price/quantity relationship.

To develop such a criterion function in a complex analytical area requires assumptions that are (a) of heroic proportions and (b) based on knowledge of behavior which we do not now possess.

For the future, of course, the implication is clear. If design models are to be successful, there must be greatly increased analysis of impacts, their incidence, choice criteria, and the trade-offs acceptable to various groups of the population. For example, in a retail market potential model the criterion problem is relatively simple and tractable. One can think of criteria such as sales per square foot, or a minimum size center, or a minimum level of service, and there is a fortunate convergence of these criteria in solution space. But, in a multi-dimensional situation like residential location, the problem is not so simple. The criteria multiply with no clear relationship among them. I believe that backward-seeking models that trace an optimum path from a prespecified end state are unrealistic except in very simple modeling situations.

Further, may I comment on a related aspect of a popular model design style? Many of us have tried to follow the examples of those successful physical scientists, the physicists who use a few key variables to describe a process. This method, however, is not applicable to a social system composed of a multiplicity of interrelated variables. Such a desire for simplicity, despite its intellectual attractiveness, demands a high price, in terms of present and future error and, perhaps, even future loss of confidence. "The pathways of knowledge," says Professor Kendall, "are littered with the wreckage of premature generalizations."

I began by saying that the way in which we plan for innovation very much depends upon the philosophical view of the problem we adopt.

The problem of developing a plan for innovation in a field that is itself expanding is cause for some alarm, but it is encouraging to note that such fields as space research, oceanography, and atomic energy have achieved varying degrees of planned and directed innovation. There are four major schools of thought on structuring such innovation. The first would allow innovation to develop opportunistically, depending upon the autonomous workings of science. More popular in Europe than in this country, this viewpoint is associated with the name of Michael Polanyi. A second approach is that taken by Dr. Weinburg, who views basic research as a technical overhead that should be borne as part of mission-oriented activities. The Bureau of Public Roads and the Department of Housing and Urban Development have reflected this viewpoint in funding, in connection with ongoing metropolitan studies, most of our research on urban models. A third school of thought treats innovation as a social overhead investment. It looks upon science from the viewpoint of the entire society which is to benefit from the research, rather than from that of an individual operation which may or may not directly be aided by particu-

lar research. This approach may have come from recognition that, as Daniel Bell put it, knowledge is really the matrix of innovation. The fourth point of view, expressed in a recent issue of *Minerva,* views science as a consumer good, a luxury upon which society may spend its extra product. In such a view, science is an open-ended and cumulative investment.

These viewpoints have been implicit in much of our discussion, but they are not as contradictory as they may seem. Rather, they are to a large extent complementary, reflecting emphasis on different aspects of science—basic versus applied research or exact versus inexact sciences. Polanyi, for example, is concerned with the pure research spectrum of research while Weinburg focuses on applied technology.

A basic step, then, is to synthesize from these viewpoints an approach to the planning of innovation in urban development modeling.

If we limit our scope to such current concerns as land use and transportation and the strategy of model design, research might be considered a technical role suitable for handling by universities, nonprofit organizations, or line agencies or their consultants. Our concern, then, would be to improve the state of the art as we develop better models. Others who use our models on their own problems would do so at their own risk. If, on the other hand, we address ourselves to the larger areas of concern—socioeconomic and/or physical—what we do must be viewed as part of a larger view of urban management. We should view these urban models as aids in the twin objectives of the management of urban development: management of urban uses and the coordination of public investments in urban space. The strategy of innovation to be recommended by us should reflect this management view.

BORIS PUSHKAREV, *Regional Plan Association*

I would like to begin with the question of what are the real issues, the substantive issues in the modeling effort? And I would like to answer this with another question, namely, how did the whole modeling process arise in the first place? It began because engineers needed traffic estimates to design highways. Now, I think the issue is how to design metropolitan areas, and this is what models are needed for, and this is what I think they should be geared to. Skeptics may argue that while engineers are, in fact, decision-makers, nobody is kidding themselves that publicly elected officials locate highways. One might say that economists do not really design economic systems, and that no planner has yet planned a metropolitan area. Let me offer two counter arguments. One is that the share of public capital investments in our metropolitan areas is rising. In New York City the share of public versus private investment is now close to 50 percent, but this investment does not present an integrated design. Thus there are increasing possibilities for influencing the shape of the metropolitan area. The other argument is that even if the model of an ideal region is never implemented, it is nevertheless extremely useful and interesting to compare it with the performance of reality, partly to see what is wrong with

the model and partly to see what is wrong with reality. So the issue is, I repeat, how to design the region.

The regional plan is what we have been worrying about for the last three years or so. As a result, we have expressed wishes for models in four areas of land use: nonresidential land use, transportation, residential land use, deliberate over space. I think the sequence reflects the relative importance of these four categories of land use for urban performance. In regard to the second category, transportation, there has been tremendous progress in this area over the past twenty years culminating in the Einsteinesque elegance of Morton Schneider's work. In residential location, we totally rely on Britton Harris and take off our hats in deference. However, the first category, the location of nonresidential land use, which is most important in shaping urban structure, has received little attention, except for retail location models. It follows, then, that we would like to focus on nonresidential land use.

I will briefly discuss how we approach the problem without having any really rigorous models for dealing with it. To begin with, we find that the standard SIC categories in which economic activity is inventoried are locationally not homogeneous. In fact, they are frequently irrelevant to location, so that nonresidential activities or nonresidential land use has to be disaggregated into some other categories which have locational relevance and which are hopefully relatively few in number, so that they are manageable. We have chosen about five categories which, in turn, are subdivided into three classes. The categories are: office employment, production-oriented goods handling employment and warehousing, retail employment, institutional employment, and other. The "other" includes locationally indeterminant activities such as construction, employment in construction, and transportation. Now, these five categories, in turn, are broken down into three classes according to the degree to which they are distributed or are not distributed in the same way as population. Class 1 is population independent, class 2 is population semidependent, and class 3 is totally population dependent Class 3 accounts for such things as local grocery stores and school teachers and elementary schools. In class 1, which is supposedly population independent, are office headquarters, central institutions such as the Metropolitan Museum of Art, and also most of the manufacturing. This sort of classification is really our only conceptual innovation in this field and we would hope eventually to develop a rationale and rigorous method of allocating these activities. Presently, all we have been trying to construct are some density gradients which represent the distribution of these things within the region. The problem is to construct density surfaces which have several peaks, and to try to play around with these future density surfaces.

There have been two problems here. One pertains to linking these three employment classes in a useful way. For example, the first could be considered as basic employment, the second as relating to basic employment, and the third as relating to both of the former categories. It would seem plausible

to relate them through some sort of accessibility measure, but this has proven to be fairly difficult. By definition, the first category is population unrelated, so there is very little correlation between its location and the location of other activities. Thus one of the snags has been the accessibility measures in relating these three mountains to each other. The other snag, of course, is the arbitrariness of locating the basic employment in the first place. You can guess that a certain amount of it would locate in Manhattan, but locating the remainder becomes a mere design exercise with no criteria for trying to distribute it in the future in a normative way. We do have a projection for these phenomena. But I think our strongest wish is to have some rigorous way of locating future office jobs; we place particular stress on this because the projections indicate that office jobs in office buildings will rise from about 21 percent of all jobs now to about 32 percent of the total by the year 2000. This has tremendous implications for the concentration of future work trips, and also for the possible renewal of old cities and other central places. In fact, the main purpose of our recent book is to emphasize the impending growth of office jobs versus the stability in manufacturing jobs over the remainder of the decade.

The other unsolved problem is the evaluation of alternate future distributions. For the future we have a glimmer of hope that Harris' system will come up with some answers on the relative performance of these alternative distributions.

In the meantime, we have been trying to play around with the transportation implications of alternate employment distributions. Here a salient point is the issue of scale. Are we talking about concentrations at the level of, for example 200 square miles or at the level of 2000 square miles? It seems that at the level of about 200 square miles it does not make any difference how the jobs are arranged in space given an even distribution of the population over the surface. We have gone through a few exercises that are similar to the ones Aaron Fleischer has done at M.I.T. and we find, for example, if one-third of the jobs are grouped in one central square mile rather than dispersed evenly or grouped in several centers, the difference in person-miles of travel is only on the order of 4 or 5 percent However, if, for example, Manhattan were eliminated by dispersing the population through the region the saving in person-miles of travel would be on the order of 20 percent or more. Now, this, of course, does not suggest that we do intend to recommend disbanding Manhattan. In fact, when we were presenting some of these things at a meeting with the Tri-State Transportation Commission, the remark was made that to cut person-miles of travel by 20 percent, it is not necessary to disband Manhattan The reduction of incomes below $5,000 would achieve the same goal, more or less, because 40 percent of the men who make over $10,000 work in Manhattan while only 25 percent of all workers do. This brings us to the issue of the cost and benefit of agglomeration in economies. Apparently the high cost, long journeys to work, performed mostly by men who make over $10,000 a year, are voluntary trips, and apparently these people get some-

thing for their effort. Thus, it is possible that added transportation cost is outweighed by the benefits of agglomeration in Manhattan. The issue of determining these benefits is somewhat problematical. In evaluating these we will attempt to test one at a time changes in the transportation system or changes in land use to see how these things reflect on each other.

Our approach, in exploring future transportation systems, is quite different from the generalized approach that was published in a description of the work of the Office of High Speed Ground Transportation. We would like to take a specific piece of hardware that might be feasible in the future and test that to see what it would produce. I am talking specifically about the pneumatic-tube system that Lockheed has been thinking about, which definitely has implications for much higher concentration of density near stations, and probably quite revolutionary implications for the entire eastern seaboard chain.

The final wish is for a model that would establish criteria for open space design within the framework of accessibility. I think that things like site quality can be translated into accessibility measures. That is, if one is on the same site as the grass and the trees, this particular kind of amenity is very accessible. If one lives in Harlem, a mile away, this kind of amenity entails certain accessibility cost. I believe that a park location procedure can be developed on this basis, given the specific propensities of children between 2 and 5 years of age.

However, I am afraid that manipulating the urban form on a micro basis within realistic limits, and without abolishing agglomeration economies, has very little effect on the overall performance of the metropolitan area. Possibly the real difference in livability and environmental attractiveness is made by architectural design at the scale of a quarter of a mile, or less. Consequently, we are trying to determine people's perception of space and density. We are trying to create a design model that will handle psychological data, but I am not very enthusiastic about it at the present time.

DISCUSSION

Kenneth Schlager opened the discussion with a call for comment on design models—the relative resource allocation which should go into their development versus development of predictive models, and the appropriateness of hill-climbing or other search techniques of design models. The subsequent discussion focused on the determination of appropriate objectives of models, translating these objectives into operational terms for use in design models, the difficulties of selecting appropriate criteria and evaluation of model output, appropriateness of hill-climbing techniques, and the use of models of subsystems rather than the total system.

Britton Harris began with a comment on possible objections to design models. "I would like to anticipate the main problem and objection I think that

people will have to design models. The greatest danger would be to have a very simple objective function, throw in a few constraints that are easy to manage, and then come up with a design that would violate important constraints that were not expressed. I recognize this, but I make two comments on it. One is that I do not think it is wise to hold up the development of design models until we understand everything about all the possible criteria. Second, I think design models should be run like an experiment. And I think if planners start to use design models in a way that permits them to be close to them, and even see visual displays of their operation, there is going to be a learning process, because if you come up with a plan from a design model that violates something that you do know but cannot express, feedback will develop when you see that you did violate something, and then you will be forced to try to express it."

In response to Harris' comments, discussion centered on the selection of proper objective functions for design models and the possibility of suboptimization resulting from use of design models because of inadequate objectives and the limitations of hill-climbing techniques. Marvin Manheim suggested, "If you ask a decision-maker for a statement of goals that you can put into a design model, by and large you are going to draw a blank. So really we need to be concerned with how we can present small numbers of alternative objective functions. Because you have a very complex space of alternatives in which there are real dangers of suboptimization, the optimum that you end up at is a local optimum and depends upon the starting point. I think it is a very real danger, but it is also a virtue in a sense. When you generate a starting point for the hill climb (or other search process) you are generating a basic theme. You still have to worry about looking at large numbers of different starting points. If you happen to have a hill-climbing procedure which ends up at a local optimum, this is a local optimum for a particular objective function and has its value."

Charles Leven responded, "I think there are two problems. One is how to discriminate among starting points with respect to a hill-climbing experiment. The other is how to design hill-climbing experiments in order to achieve an optimal position with respect to that starting point. I think the notion that search models are just trying out different sets of objectives as if this were kind of a casual experiment is kind of bizarre. I suspect selecting objectives is much more difficult than hill-climbing problems. The sad fact is that we do not have an apparatus for discriminating between different starting points. What is needed in order to discriminate among starting points is a theory of the city which would relate to city planning the way that economics relates to business administration or the way that physics relates to engineering. In the absence of this body of theory we tend to become mesmerized with hill-climbing operations."

Taking off from the slightly different positions stated by Manheim and Leven, the discussion centered on the question of adequate definition, or

specification of objectives for use in operational models. It was generally agreed that two major problems exist. The first is the difficulty of identifying all of the relevant objectives to be considered The second is the inability at present to evaluate adequately the outcomes of models because of the difficulties in identifying and measuring externalities, and the lack of simple criteria. Harris summed up, "Choosing between starting points and hill climbing both have a common problem. How do you evaluate the objective function. Whether you want to formalize it and call it an objective function is not important, but if you call it criteria of choice, or whatever name you want to put on it, you still have to evaluate. People start talking about evaluating land use plans, and say we are going to evaluate the transportation efficiency and then they stop. Now I do not know whether this comes from our background in transportation planning or from the fact that we are dealing with a lot of intangible values, but I think that we ought to be talking about how we can measure the quality of life in very realistic ways."

Michael Tietz switched the topic to the design of subsystems pointing out the tendency of designers to break problems into smaller sections which have internal coherence. He noted that work was proceeding on subsystem components of the city such as hospitals and libraries and raised the question of whether it was possible to incorporate institutional subsystem components directly into the design process given the complexities of the subsystem components and the limitations of the design models. Schlager replied based on his experience with water and waste treatment subsystems that this would depend on the ability to incorporate the linkages of the subsystems components with the total system into the design model. The specification of the value of these linkages might then be handled in the overall design and considerable freedom of detailed subsystem design would be retained. Stevens then suggested that emphasis on subsystem analysis presented a danger to progress on analysis of the total system, and that, in many cases, very little information about a subsystem was actually needed to incorporate it into the total system analysis. He proposed that some form of general systems analysis which would take into consideration the amount of information needed at that level about each system would be most appropriate given the likelihood of using gross aggregative models.

Alonso raised the point that often the discussion of objective functions indicated that these were cost minimizing functions. This is due, in his opinion, partly to the strong association of land use models with the transportation modeling experience, and partly reflects the traditional work in planning which concentrated on defining problems and then finding ways to alleviate or minimize them. He suggested the need for developing positive goals and objectives rather than the negative objectives of cost reduction.

Stevens objected saying that he felt current model-building efforts went far beyond simply minimizing costs and pointed to the Herbert-Stevens model as

an example of a model that "was specifically for the purpose of avoiding simply minimizing cost . . . for looking at a whole package of values which people get out of urban locations." Stevens suggested "that perhaps we have not gone far enough in trying to do the much more difficult job of evaluating what kinds of satisfactions people get out of living in urban areas and what kinds of values they have." Responses in agreement with Stevens' position came from Schlager, Harris, and Garrison. Schlager suggested that direct cost functions tended to become relatively less important and the constraints more important as the model-builder's understanding of the problem increased. Harris pointed out that the current version of the Herbert-Stevens model maximizes consumer surplus subject to market clearing constraints and consumer preference, and does not minimize transportation costs or rents. Garrison commented on the duality of minimization and maximization and argued that dealing with optimization problems "forces us into looking both positively and negatively at the same time."

Switching the topic, Leven suggested that several dangerous ideas seemed to pervade the discussion. One is the idea that "a plan for a city must be concerned with every aspect of human existence which goes on in the city." He argued that the task of planning should be "to use physical arrangement and connective tissue (transportation and communication) to make transactions efficient." Turning to the proper basis for planning he argued, "We are not looking for the science of man, we are looking for the science of an urban region which describes the functioning of urban concentration independent of a lot of other functioning of human beings." Leven cited as a second danger "the notion that in order to make large decisions one must be able to forecast the future." He suggested rather that more reliance should be placed on simulation models to be used "for analyzing consequences of actions in a situation where you have no behavioral model." Garrison suggested as another danger in the discussion the idea "that there is such a thing as a general model that exists apart from the society in which we find ourselves," partly in response to Leven's second point. He argued for the need to make sure that theory development was oriented to specific, present problems. Harris, reacting to Leven's first point, argued that emphasis on transactions was misleading—that a city provided both transactions and site, and that "even if we are only talking about location problems the essence of the problem is the trade-offs for businesses and households between space requirements and interaction requirements." He argued further the need to look at space related activities, including enjoyment of the environment, recreation, work, etc., since "these things added together are the qualities of life in which the consumer of space is interested, and since they influence the operational aspects of the city in which the developer is interested.

Manheim suggested the need for distinguishing "between theories which explain how the urban system works and theories which prescribe what a desirable urban system should be like." He argued the desirability of using opti-

mum-seeking design models to explore alternate urban patterns, and the need for a balance between "heuristic design techniques for inventing basically different kinds of solutions and operational analytical techniques." Leven agreed but suggested that model outcomes for the total system need not be detailed. Schneider added, "What we really want to do is find ways of breaking the total system into subsystems such that we can make general policy decisions about subsystems and delegate detailed decision-making about these subsystems to groups. But we want to do this in such a way that the overall structure is in some way consistent." The discussion ended on this note.

In summary, the discussion demonstrated that while there was general consensus among the participants on the desirability of pursuing both design (or backward-seeking) models and projection (or forward-seeking) models, at both the general, total urban system scale and in terms of urban subsystems, dealing with broad objectives of human welfare and with limited objectives of operational efficiency, there was little agreement on the relative importance and priority for work on one or the other aspect of any of these three dimensions of modeling effort.

* * *

The framework for discussion in the eighth session was set by Britton Harris as chairman. Two main topics dominated—the construction of nonresidential land use models and data requirements for models with particular emphasis on problems classification and aggregation of data. The discussion has been summarized by selecting comments of the participants.

NONRESIDENTIAL LAND USE MODELS

JACK LOWRY

I want to talk to the issue ot modeling manufacturing location, open space location, and nonresidential land uses. These have proved particularly intractable in the sense of devising some system of guessing where these things are going to be. I think it was reasonable to try this for a while, but it seems to me that we have probably tried about enough. It is not clear to me that we can guess where these things are going to be, with or without the aid of the model. It seems to me fairly reasonable that we take a quite different tack and say, "give me not the job of guessing where these things are going to be but the job of devising some institutions which will force them to go where you want them to, *i.e.*, designing zoning regulations, tax policies, industrial park promotion policies, schemes for municipal designation of open space, and so forth." I do not see much utility in trying to predict whether a firm is going to put a plant on the west side of town or on the east side of town. With a choice like that, you are going to be wrong in a big way if you make a guess. It does not seem to me reasonable to hold the model-builder responsible for being able to predict this kind of thing.

BORIS PUSHKAREV

I would like to briefly respond to Lowry's point. For manufacturing location, the point was brought out previously that it is the scale of the areal unit that one is dealing with that is important. If one deals on a parcel basis, Lowry is completely right. But if one deals, let us say, on the basis of 100 square miles or at least 50 square miles, the problem of prediction becomes less intractable. On open space, I think it is not so much the size of the open space as the criterion of how much of it is good, because I do not agree with current open space standards. They just say that one ought to have so much open space, without any regard for use of this space, location of any particular population, density, and so forth It seems that based on the use of open space in areas where it is readily accessible one can develop much more substantial criteria than ones used up to now.

RONALD GRAYBEAL

I think Lowry's point is most applicable for those large manufacturing firms for which you do care where they locate, and thus you could use his suggestion that if you care enough where they locate, then devise some policies to guide their location. But how many of the manufacturing firms fall into that class? It may be that there are some—maybe most—that do not fall into that class, so you still have the problem of locating them.

Let me describe very briefly a method that I use in the Honolulu industrial submodel. I had 10 manufacturing industries I simply ranked them by their ability to pay for their site as evidenced by where they are presently located assuming that their present location is an equilibrium, that is, they are satisfied with their present location. I estimated what I called preference functions containing various accessibility and land value variables for each of these ten. I estimated these preference functions on cross-sectional data, recognizing that this is a hazardous thing to do for time series forecasting purposes; but in the absence of alternative data, I did it anyway. I allocated my manufacturing industries by simply taking that one which would pay the highest price for land, and using the preference function found those areas that, according to this preference function, were most appealing to this type of industry.

Let me conclude by saying that I think modeling is an art; and it is the ability to combine limited data, the purpose of the model, and limited research resources in some kind of an optimal fashion.

DAVID SEIDMAN

I want to try to tie together some thoughts I have had on the significant factor in locational modeling which is perfectly applicable to nonresidential land use. To me a critical consideration is the size of the decision-making unit, and one reason I think we can construct traffic models more easily than locational models is that in the traffic model the individual trip maker is the decision unit, whereas very often in location it is not. The individual household may

not be the decision-making unit; perhaps the developer is. In large manufacturing plants the decision-maker is not each employee, it is the board of directors or the president, and the smaller the number of decision-makers, the less the law of large numbers helps you in cancelling prediction errors. It is for this reason that I suspect that it may well prove easier to control this phenomenon than to predict it. There is another process which I think makes it difficult to predict location and which may apply equally to residential and nonresidential location. To me certain locational phenomena begin with a random sort of selection, and then are followed by a quite nonrandom process. For example, the introduction of a Negro family into a suburb is an essentially random phenomenon. But once one Negro family is located, the likelihood is that other Negro families will locate by a nonrandom process. This is naturally a very difficult phenomenon to predict, since you have a large number of locations dependent essentially on one randomly chosen event. This is simply an argument for the difficulty of modeling this process, and especially modeling certain kinds of nonresidential locations.

STEVEN PUTMAN

I have an objection, not so much to Lowry's saying that we are guessing about an industrial or nonresidential location, because I think in a large sense we are, but I object to his throwing up his hands so quickly. I agree that there are not any really good statements about urban economics that allow you to say where nonresidential location is likely to occur. But, rather, there is probably in every urban area a reasonably well-established, traditional land brokerage operation going on where there are people in the city who sell land for new facilities coming into the city or who provide locations for firms moving around in the city. If we could in some way investigate the means by which these people make their recommendations to people looking for property, we might then have a good description of where things are likely to locate. This was basically the kind of thing that I tried to develop in the intra-urban industrial location model that I did in Pittsburgh. I think that in some senses it did locate things where it seemed eminently likely that they would locate, but I think maybe even more importantly it did provide some good guesses as inputs to the residential location aspect of the overall model.

BRITTON HARRIS

I think we are to a certain extent addressing different problems. Lowry was talking about very large plants. Steve Putman and Ron Graybeal are more concerned with small plants.

BENJAMIN STEVENS

There are clearly parts of manufacturing which are easier to predict than other parts—the activities that are very dependent on agglomeration economies, the small firm activities that locate downtown and spread themselves around

certain centers of activities downtown. Certain parts of retail activity also behave in a regular way. It is the large units—the shopping center is perhaps more like the location of a large manufacturing enterprise than like the rest of retail location—that are difficult. I think you have to talk about these things as a group, depending upon how many there are, how large the units are, and how discrete they are. I think that the investigation of location patterns of industries in metropolitan areas and the way these patterns are changing can suggest that there is a bit of logic to the pattern that would certainly allow you to assign a much higher probability that certain kinds of sites would be used. It may be guesswork, but it is guesswork with a probability distribution attached to it.

T. R. LAKSHMANAN

I have a comment on the question that Boris Pushkarev raised on recreation land use. I want to briefly report on a study we did on recreation planning in Connecticut. Very early in the game they accepted the point that Pushkarev raised, namely that existing standards were extraordinarily insensitive to the changes taking place in the area of recreation usage. So they posed the question, could we in any way explore the problem of how we would evaluate alternative plans of outdoor recreation. What we tried to do was look at the problem in terms of the activity participation rates for people for different kinds of activities. The basic ideas behind this model are that a person or household, given a certain amount of time, trades off different kinds of activities in the sense that they have to come out of the same time budget; and the participation rate in any particular activity is a function of the total amount of recreation activities participated in. It is also a function of the income level of the family group. The data for implementing this model were collected by a special telephone survey. We were able to estimate total requirement for land assuming that there was some sort of equilibrium between the total amount of participation days in the state today and the total amount of land that is available making allowances for travel in and out of the state. Alternatives were then developed and the potential concept was employed in a recreation trip model to evaluate usage of recreation sites.

DANIEL BRAND

I have some items of information as to the regularity of employment location. Let me cite some examples of some factor analysis output that we ran in Boston. On the city and town level—152 cities and towns—for 1950 and 1963 by 2-digit SIC manufacturing employment classes, as I recall, all but 3 of these 2-digit SIC categories for 1950 fell into one factor and all but 2 fell into the 1963 factor—the same factor. The point that I want to make is that there is a great deal of regularity operating here. We also ran factor analysis at the 626 zone level for 2-digit SIC employment. We were quite pleased that the divisional aggregations seemed to be falling in the same factor, exhibiting

similarity of locational behavior. Where certain 2-digit SIC categories within a division did not fall in that divisional factor, it was very interesting to try to rationalize why they did not and there was a lot of insight gained as to why they did not. So I do feel there may well be some hope for applying statistical techniques to locating firms.

WILLIAM GOLDNER

I would like to mention the efforts we are doing in this same direction. We are using the size distribution of firms by individual industries as the basic source of information to generate a firm life-cycle concept in which firms find it necessary to relocate after they reach a certain maximum size threshold, die when they decline below a certain threshold, and move within this range on the basis of a Markovian process. This has already been formulated and is in the process of being programmed.

CLASSIFICATION AND STRATIFICATION OF DATA FOR MODELS

MORTON SCHNEIDER

Everyone talks as though there is some very clear distinction, some property of activities, that makes one activity utterly different from the other, and that this continues on through the whole SIC code. I do not quite know why we are talking about these distinctions. Is there something about these differences that makes it useful to consider them? I know there are differences in quality and differences in perception. You can look at things and say that this is more or less one or the other. But so what? Does it mean that you are able to, for example, predict how they will behave differently. I am addressing myself really to the whole question of stratification. Why form a stratum unless you can do more with the stratum than you can without it?

MICHAEL TIETZ

I would like to point out that there are some kinds of things which are located as a public decision, that is, as a result of a decision to spend some part of the public budget rather than some kind of a market process. And that these things have to be located with respect to some kind of rationale which perhaps is not explainable in the same way, partly because you are operating in effect inside budget constraints. This I think would be one reason for making distinctions. This is simply a convenience distinction—convenient for thinking about things.

BENJAMIN STEVENS

If you say that residential and nonresidential is an arbitrary classification that does not tell you very much, I would argue that some sort of classification of locators is probably useful and that the locational characteristics are different.

But the important distinction may be the importance of access in the location decision of the household and the location decision of the firm. Perhaps relative access is much more important to certain kinds of activities. I would define nonresidential activities as those things for which access is more important relative to other site characteristics than it is for residential activities. In other words, accessibility itself and the values that go with accessibility for some activities are quite different from the importance of accessibility to the individual household.

MORTON SCHNEIDER

I quite accept that distinction, but then I would ask, if you can make such a distinction why not use it instead of residential or nonresidential class? Why not measure the importance of accessibility and attach a number to an object you are talking about, saying that it falls into a particular accessibility level?

BENJAMIN STEVENS

I agree with you, and it is because I think you actually can attach such a number that I think Lowry is wrong and that in fact you can predict much better the location of these so-called nonresidential activities than he indicates.

BRITTON HARRIS

I happen to disagree with what Schneider and Stevens just agreed on, for a number of reasons. Residential space is an important locus of family life which is a basic social unit and has certain specific social qualities which are not unique to it but which differ from many of the social qualities of other located activities. Therefore, from the whole point of view of policy-making and legislation, and exposure of the population to many aspects of our current life, it has to be considered separately. This is perhaps a planning rather than an analysis question. I also think that there are differences in the decision unit. If we take a decision view of the processes which go on in metropolitan space, then I think that we have to distinguish institutional decisions, decisions by profit-making units, decisions by households, and so on. And I think there are many other dimensions to this problem Some of them are connected with planning. Some of them are connected with legislation. Some are connected with locational decision-making. Some are connected with the kinds of phenomena that Schneider and Stevens were agreeing are directly important. And I agree too, but I do not agree with their conclusion.

JOHN HAMBURG

It seems to me that if there is some reason for making a distinction in these activities, that you can make certain kinds of distinctions if you think they are important distinctions for the particular purposes that you are working at.

JACK LOWRY

I think it is quite reasonable to ask if there is some other way of stratifying which would be more useful for, or as useful, for modeling purposes. But I might make the point that you at least have the option of subdividing what we have here called residential into internally homogeneous groups by whatever the property is that you are interested in, and the classification of residential, I think, may have some obvious uses as an output. In other words you want to be able to reaggregate your forecast in terms of the possibly nonfunctional classification. So it seems to me that the point is not to forget the classification residential, but to ask if it might be a good idea to divide it somewhat.

* * *

Discussion shifted from general concepts of approaches to classification discussed by Schneider, Stevens, and Harris to the specifics of the existing Standard Land Use Classification System used by the Department of Housing and Urban Development and the Bureau of Public Roads. From this initial focus discussion shifted to the desired characteristics of land use or activity classification schemes. There was general agreement in the discussion that the coding of attributes of the objects being surveyed was the preferable form of recording data so that maximum utility could be gained from it. The Standard Land Use Classification System was criticized on the grounds that although it is a code it is based on names of objects rather than on a structure of attributes or variables (Tietz). Another aspect of the question of land use classification raised in the discussion was the relation of the classification system to data collection. It was suggested that a general coding scheme is an unsatisfactory guide to data collection because "only those attributes are collected (by agencies) that are necessary to sort data into a pre-established list of classes" (Harris).

A general question (Harris) underlying the discussion of data collection and classification systems on which there was no consensus in the discussion was the utility of developing large scale "data banks" containing a description of urban areas potentially useful for many purposes versus collection of data primarily in terms of pre-specified uses for it in models and other analyses designed to treat particular problems. In terms of model design, it was suggested that an economic analysis "evaluating the cost of additional information and the way the additional information will contribute in the context of the model" was necessary (Goldner). There appeared to be general agreement in the discussion that the specification of a "minimum data set", suitable at least for transportation and land use modeling, could be developed if some additional research effort were directed to this question. There was also apparent agreement that time-series data on metropolitan areas was essential for further development of models, but that this kind of information need be developed in detail for only a limited number of metropolitan areas and the knowledge gained could be transferred to other areas

The discussion on the general problem of sequencing the specifying of an adequate data set for modeling and developing an adequate modeling system which in turn defines the data requirements was summed up (Seidman) as being necessarily a cyclical process in which data improvements lead to refinement of models and these to further specification of data requirements.