B. Equilibrium Models of Retail Trade Location

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I want to give a somewhat anecdotal description of an equilibrium model of retail trade location which I more or less accidentally developed about two years ago. This model is in many respects remarkably parallel with the model developed by Hansen and Lakshmanan and described in their article in the May, 1965, issue of the Journal of the American Institute of Planners. At the same time, while it embodies some of the basic concepts of central place theory, it stands in marked contrast with the model discussed by Brian Berry.

For about ten years I have been troubled by an implication of theories of trip distribution which it seems to me had never been adequately examined. If we assume that these models describe a determinate pattern of behavior and if we assume, for example, that the location of residences is given, then intuitively it might seem to follow that there could be at the most one distribution of (say) shopping trip opportunities which would be consistent with these assumptions. In other words, if we define a set of shopping opportunities and distribute trips to them from places of residence, then in general we would not expect the arrivals to be "balanced" with the opportunities. In terms of economic adjustments, this would naturally lead to the expansion of some retail trade centers and the contraction of others.

I finally decided to put this question to some kind of test, and first using a gravity model and then a trip distribution model of my own devising, I did so. These tests produced a couple of interesting surprises. In the first place, in many cases the first iteration produced arrivals which were highly correlated with opportunities (R^2 over .95), yet if the distribution was adjusted repeatedly until balance was achieved, the shape of the distribution changed greatly. The same final equilibrium distribution was arrived at regardless of the starting distribution, thus demonstrating that there was a grain of sense in the original hypothesis, Second, and equally interesting, the use of this model without any assumptions about economies of scale or agglomeration nevertheless produced peaks or clusters of retail activity in a geometric arrangement. This interesting conclusion seems to say even more about the geometry of retail trade concentrations than does central theory.

Up to this point there are only two differences between this model and the Hansen-Lakshmanan model. A trivial point is that the iterations of equilibrium in my model are conducted wholly inside the computer, while these iterations were managed by hand on the repeated runs by Lakshmanan and Hansen. More important perhaps is the fact that selected locations were provided in a predetermined pattern for the Lakshmanan-Hansen model, while the pattern in the Harris model developed naturally out of the geometry of the problem.

We now proceeded to attempt to fit the model to detailed locational patterns by two-digit SIC categories for all nonmanufacturing. The fitting process required that we generate different parameters for each SIC group. This barred us from using the Lakshmanan-Hansen recourse to trip distribution parameters because these cannot be derived for small trade groups. In any case, it

it is my feeling that the growth of trade centers involves more than considerations of trip making. In our calibration, therefore, the marginal distributions of supply and demand are the only observations, while the interactions are implicit in the model and necessary for its operation. It happens that this creates a difficult job of parameter estimation which we solved by devising a new optimum-seeking method.

We also found it desirable to make two other important modifications of the model. In the first place, we adapted it to allow for two strata of demand, one from residential income and the other from nonmanufacturing employment, both geographically located. The second stratum of demand is introduced on the assumptions, first that a certain amount of shopping and personal business originates in the place of work, and, second, that the interaction between businesses is important for business services. The weights of these two strata are determined in the fitting process and in fact reflect the usual preconceptions about the nature of demand of various services. The second modification of the model was to introduce a concept of agglomeration economies in the form of a variable which represents the over-all density by area of retail opportunities and which intensifies or diminishes the attractiveness of opportunities in any particular SIC category. This clearly introduces an element of circularity into the model and probably destroys the uniqueness of a location outcome, since these may now depend on the choice of a starting configuration.

The empirical results from fitting this model at the Penn Jersey Transportation Study were extremely interesting. We have used initially a 23-area breakdown of the Philadelphia metropolitan area and have made preliminary fits for a large number of SICs on a 73-area breakdown. The model seems to be an excellent sieve for sorting out those industry groups which do not equilibrate their location to market forces. An examination of the cases with low R^2s reveals deviant areas, and a knowledge of the region supplies obvious explanations for these deviations. In most other cases, the R^2s range from .85 to .98, with most of the better explanations applying to the more centralized and specialized SICs (owing to heteroscedasticity).[1] Using the same three independent variables throughout, distributions of very different characters were reproduced well. Surprisingly, there was no very great decline, and in some cases there was a marked improvement, in the R^2s when changing from a 23 to 73-area breakdown. In most cases, the parameters did not change markedly.

A little reflection will show that this model preserves several important features of central place theory. It assumes that trade location is the result of the location of demand and of the willingness of demanders to travel or interact. It assumes a certain type of agglomeration economies. On the other hand, it does away with any assumption about market areas and in fact creates overlapping fields of influence which are in my opinion much more realistic. In a sense it solves the problem of finding the locations for centers which Berry discusses in his remarks, but because of the circularity of the model, this solution may be partly fititious. It is more sensitive than central place theory to possible changes in the transportation system, and important consideration in building policy-sensitive models. On the other hand, the attitudes of consumers toward economies of scale and agglomeration are reflected in the parameters derived from any particular set of

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1 R^2 in this study is defined as one less the variance of the residuals divided by the variance of the original distribution.

observations, and are probably just as artificially unchanging in this model as in central place theory.

Although the techniques for fitting and using this model are in a sense quite sophisticated, it really rests on very primitive assumptions and has a primitive structure. There would be a great deal of room for further experiment and modification of the model and for a careful examination of the relations between its theory and other theories of retail trade location.

References

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Lakshmanan, T. R., and Hansen, Walter G., "A Retail Market Potential Model," Journal of the American Institute of Planners, Special Issue, XXXI, 2 (May, 1965), 134-43.

IV. Some Notes on Land Use Models

The two summaries reproduced below are drawn from Committee records. Several other models were discussed in the same sessions in November 1964. Some of these have been written up in the special issue of the Journal of the American Institute of Planners, May 1965, devoted to land use models. For example, Kenneth J. Schlager's presentation on "A Land Use Plan Design Model" appears in that publication, as does a more complete presentation of John R. Hamburg's discussion of "An Opportunity-Accessibility Model." Also appearing in the same issue is William L. Garrison's "Urban Transportation Planning Models in 1975" which he outlined in Committee sessions in November 1964.

A. The Penn-Jersey System of Models

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I am currently a part-time consultant to the Penn-Jersey study. It is my feeling that the influence which the Penn-Jersey study has had in the field of transportation planning is somewhat out of proportion to its recorded accomplishments, if you neglect influence as an accomplishment.

The P-J study was organized in 1958-59 by the highway departments of New Jersey and Pennsylvania in response to certain key planning issues in the Philadelphia area and a general dissatisfaction on behalf of many to the attention given to transit planning. At this time there was very little attention given to the use of EDP in the transportation planning field. The 7090 did not yet exist.