Volume Title: The Detroit Prototype of the NBER Urban Simulation Model

Volume Author/Editor: Gregory K. Ingram, John F. Kain, and J. Royce Ginn

Volume Publisher: NBER

Volume ISBN: 0-870-14258-5

Volume URL: http://www.nber.org/books/ingr72-1

Publication Date: 1972

Chapter Title: The NBER Urban Simulation Model

Chapter Author: Gregory K. Ingram, John F. Kain, J. Royce Ginn

Chapter URL: http://www.nber.org/chapters/c3498

Chapter pages in book: (p. 1 - 8)

1

THE NBER URBAN SIMULATION MODEL

ANALYSTS OF URBAN PROBLEMS have perceived the possibility of using high-speed computers to describe or model the city for nearly as long as there have been computers, and tens or even hundreds of models have been proposed or built. Of the large number of computer simulation models that have been proposed, developed, or used to analyze urban phenomena, only a handful have been the work of economists. As a result, economic theory and behavior are rarely evident in previous urban simulation models.

The NBER Urban Simulation Model is a clear exception to this pattern. Even though large models of urban areas may not be very novel, the NBER model is nearly unique among them because of its economic content. It is deeply rooted in economic theory; the utility-maximizing households and the profit-maximizing firms that pervade microeconomics are the basic building blocks of the model. This monograph describes the Detroit Prototype, the first of a family of computer simulation models of urban growth and development undergoing refinement at the National Bureau of Economic Research.

Our motives in developing the NBER Urban Simulation Model are at least three in number. First, as economists we want to enrich the corpus of economic theory and to increase its usefulness as a tool for understanding the processes of urban growth and development. Second, as model builders we hope to advance the art of building large computer simulation models. We are strongly persuaded that computer simulation models will revolutionize economic theory and analysis in the next few decades. Application of computer simulation techniques to the analysis of the complex economic and social behavior of the city is only one, albeit one of the most essential, of many possible applications of computer methods to the development of a richer and more pertinent economic theory. Therefore if we contribute significantly to the knowledge and techniques of representing complex economic systems, we will have advanced economic science. Finally, we wish to use our computer simulation models to analyze the difficult and perplexing problems of urban growth and decay, to evaluate specific programs or policies, and to consider broad strategies for dealing with our cities. This third objective is listed last not because we consider it to be least important, but because progress toward reaching the first two goals logically must precede the development of a reliable and truly useful policy analysis tool.

The temptation to claim we have reached the third goal is very great, but we feel we could do no greater disservice than claim to have accomplished more than we have. Incorrect and misleading computer simulation models are capable of more harm to the public policy process than no computer simulation models at all. Unfortunately, too many models of this kind exist already, and there is some indication they have misled policy makers about the nature of urban problems and the effectiveness of various policies.

Although much remains to be done, we have made more progress during the past three years toward the goal of providing a truly useful policy tool than we could have imagined possible. This progress is attributable in equal parts to the growing body of systematic research on the behavior of households and firms, to the revolutionary increases in the size and speed of high-speed computers, and to the increasing availability of systematic data on household and firm behavior and on the city. The latter is, of course, a direct result of the growing use of computers as well. The Detroit Prototype would not have been possible had any of these three critical ingredients been absent.

The model described in this monograph is not yet suitable for the analysis and evaluation of public policies because our knowledge of metropolitan phenomena is still insufficient. However, our experience in the investigation of urban problems and in the construction of computer simulation models over the past several years has impressed us with both the value of systematic analyses of urban behavior and the promise of computer simulation models as a tool for analyzing the problems of the city. Indeed it may be the only tool capable of addressing many of the city's most fundamental problems. We are equally persuaded, however, that to develop truly useful models will require a commitment to research, testing, and development over several years of a kind that has not as yet been forthcoming. We hope, therefore, that this volume conveys the promise and potential that computer simulation models have to assist in the design and evaluation of urban programs and policy.

A Brief Description of the NBER Model

The NBER Urban Simulation Model is a generalized, policy-impact model based on empirical research for a large number of cities. It represents aspects of firm, household, and market behavior common to all cities. Although the version of the model described in this report makes extensive use of data collected in Detroit during 1960–65, the modeled city cannot be regarded as Detroit. A reasonably consistent description of a city in terms of employment, population, housing, housing prices, and transit and road networks was required to calibrate the model, and Detroit was a convenient source of data for this purpose.

The model is designed to simulate major changes in urban spatial structure that occur over periods ranging from ten to fifty years. In designing the model, our principal theoretical interest has been to understand the effects on the spatial structure of urban areas of long-term trends in the level and spatial distribution of employment, of changes in transportation technology, of increases in income, and of the growth in employment and population. Our principal policy concern is with the indirect and relatively long-term impacts that various public policies would have on urban spatial structure, on investments in residential and nonresidential capital, and on changes in the characteristics of neighborhoods.

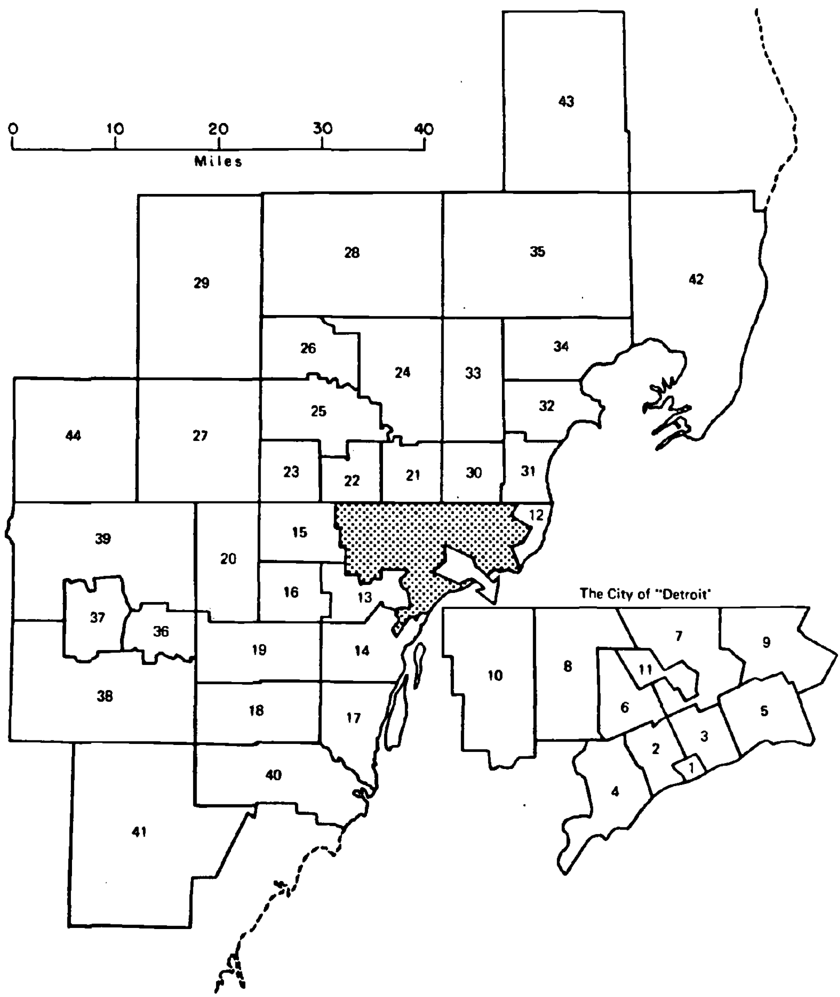
The model begins with a description of the spatial structure of the modeled city at a point in time and modifies this structure over a period of years by simulating the location and investment decisions of firms, households, and housing suppliers. The number of years covered by the simulation and the period of time represented by each iteration depend on the objectives of the simulation. For both technical and budgetary reasons, the period of time represented by each iteration will usually be greater for longer simulated periods. In order to simulate the effects of particular policies within a ten-year period, each iteration of the model would probably represent a year. However, for replicating the effects of a policy or major public investment over a period of twenty or thirty years, each iteration might represent two years or more.

The NBER model differs from previous urban simulation models in several respects. The most important is its explicit representation of the structure and behavior of the housing market. Previous models have represented household location decisions and changes in urban spatial structure by elaborate statistical descriptions, usually with little or no theoretical justification. Although market behavior may be implicit in these empirical regularities, concepts such as supply and demand or prices are rarely included in the models. In contrast, during each iteration period the NBER model directly simulates most of the important types of market behavior which influence urban spatial structure. These include:

1. Household decisions to move
2. Determination of housing prices by housing type and location
3. Determination of the types and location of housing selected by new and moving households
4. Filtering of the housing stock from one quality stratum to another
5. Renovation and modification of the housing stock
6. Construction of new housing
7. Changes in the pattern of interzonal travel to and from work

The hypothetical metropolitan region included in the Detroit Prototype is divided into 19 workplace and 44 residence zones. The residence zones, shown in Figure 1.1, include the entire area of the region. The 19 workplace zones, shown in Figure 1.2, are aggregates of the 32 inner residence zones. The 12 peripheral zones, which are assumed to contain no employment, serve only as residence zones. The modeled city contains only employed households, and each household has only a single worker employed at one of the 19 workplaces. Each household in the modeled city belongs to one of

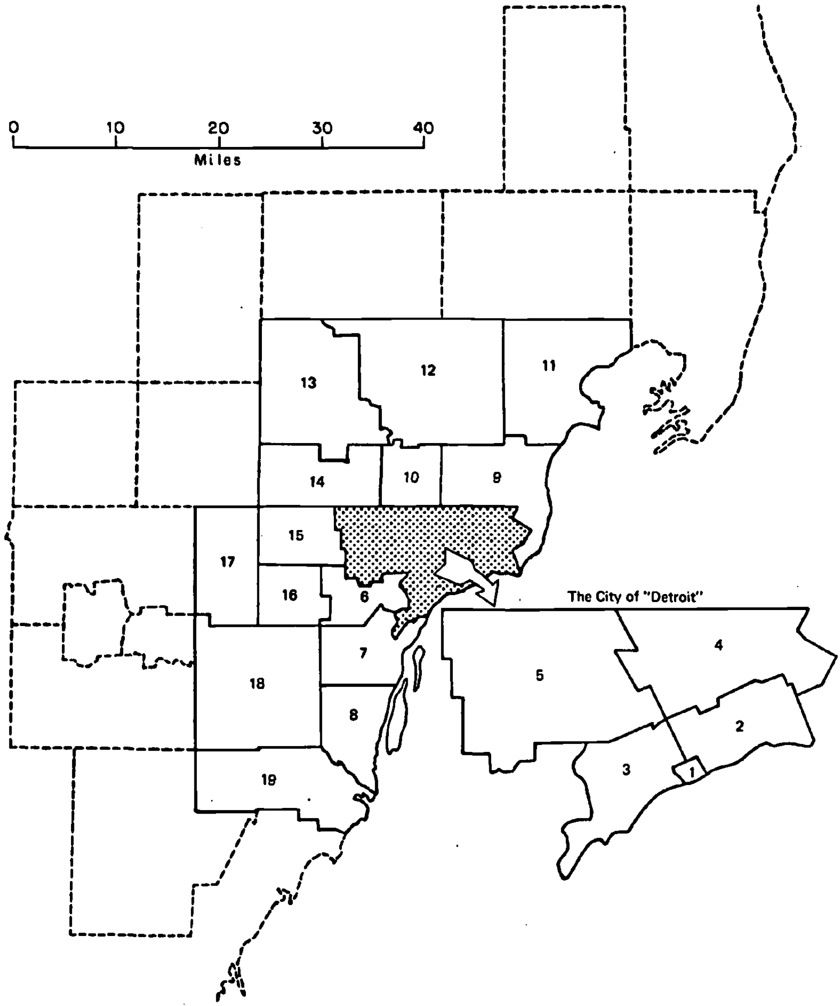
Figure 1.1
Residence Zones for the Detroit Prototype



72 household classes defined by family size, family income, and the education and age of the head. Each household lives in one of 27 distinct types of housing defined by structural type, number of rooms, quality, and lot size. The worker travels to and from his workplace by one of two modes of travel. The modes are depicted in terms of interzonal travel time and cost.

The Detroit Prototype obtains market prices for each of the 27

Figure 1.2
Work Zones for the Detroit Prototype



housing types in 44 residence zones during each model period and uses this price information in determining the demand by housing consumers for each kind of housing in each residence area and the response of housing suppliers to this demand. Housing prices and access costs influence the choice of both housing type and location by new households, immigrants, and intrametropolitan movers. The rate at which the housing stock in a particular neighborhood is improved or allowed to decline in quality depends on the relative profitability of various maintenance policies for landlords and resident owners. Relative profitability, in turn, depends on the relative prices of housing of each quality stratum in each neighborhood. More substantial physical modifications of the existing housing stock, such as the conversion of existing structures and new construction, are also based on the profit which housing suppliers can expect to obtain from engaging in each possible supply activity in each residence zone or neighborhood.

For each type of housing during each time period the model seeks to satisfy a target demand that includes a normal vacancy rate. Vacancies can fall below this normal level either because the provision of some housing types is not profitable enough or because large numbers of a particular kind of unit are transformed into other kinds of units. The result will be an increase in the price of these units in the next period.

Besides representing the supply and demand sides of the housing market, the model is designed to assess the spatial implications of exogenously specified employment distributions for metropolitan development. It is not designed to assess the effects of changes in the distribution of households upon industry location or even to evaluate the effects of changes in technology, income, and tastes on industry location.

As is detailed in Chapter 9, the next version of the NBER Urban Simulation Model will make population-serving employment endogenous.[1] This extension of the model can be accomplished easily since the locational determinants of population-serving employment are well documented.[2] Modeling the locational decisions of manufacturing, wholesaling, central office, and other basic employment is, however, a different matter. There is widespread agreement about the primacy of these locational decisions in

1. In our use of the terms "population-serving" and "basic" we follow the convention used by Lowry, *Model of Metropolis* (see the Bibliography at the end of this book for the complete reference to this and all other works cited).

2. Neidercorn and Kain, "Suburban Employment and Population, 1948–75": idem. "Econometric Model of Metropolitan Development": idem. "Food and General Merchandise Stores"; Berry and Pred, *Central Place Studies: Bibliography;* Berry, "Commercial Structure."

determining urban spatial structure, but the determinants of location of basic employment within metropolitan areas are poorly understood.[3]

Uses of the NBER Urban Simulation Model

The NBER Urban Simulation Model should provide valuable insights about the probable effects of a wide variety of proposed public policies. For example, the model can be used to evaluate the effects of alternative transport investments on the locational decisions of urban households, on the kinds of housing they consume, and on the density and structure of urban development. Similarly, the model should be useful for evaluating a wide variety of housing programs. Among the most important of these are programs, such as housing allowance schemes, that seek to improve housing conditions by increasing the purchasing power of low-income households. A central concern about these proposals is that the subsidies may not increase the supply of housing; instead, they may simply increase prices and enrich existing property owners.

A variety of other programs—most notably the urban renewal and model cities programs—are concerned less with improving housing standards generally than with improving the quality of particular communities or neighborhoods. The NBER Urban Simulation Model, with its emphasis on the spatial dimensions of the housing market, is ideally suited for evaluating both the direct and indirect consequences of such programs.

3. See Brown et al., *Empirical Models*, for a discussion of this question.