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USING ECONOMIC SIMULATION TECHNIQUES IN HOUSING ANALYSIS

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Purpose

Housing has been examined from many perspectives, including sociological, psychological, historical, and economic. This paper will introduce a framework for looking at housing as it relates to a regional economy.

The purpose of this study is to explore the use of computer simulation in housing analysis. Specifically, the objectives of this paper are to: (1) describe the significance and potential contributions of using simulation as a research technique in housing analysis; (2) describe an existing economic simulation model and the operationalization of its housing components; (3) present the results and interpretation of a specific housing simulation scenario; and (4) discuss potential future application of the model.

Importance of Simulation Techniques in Housing Analysis

The potential for simulation modeling in social science research is beginning to be included as an alternative style of research in social science methodology literature (Chen, 1983).

> Computer simulation would seem to be especially valuable in the area of social and environmental planning. To the extent that it is possible to construct computer models of social processes, prospective social change might be tested out by computer prior to trying them out in real life. The importance of this has become particularly evident in recent years as we have discovered that well-intentioned social change often has unhappy inadvertent consequences. (Babbie, 1975, p. 290-291)

Interest in simulation models has increased with the advent of large-scale computers capable of complex calculations. In a methodological context, "simulation may be described as the process of conducting experiments on a model of a system" (Emory, 1980, p. 354).

Computer simulation has been suggested by Morrison (1975) as an application of an analytic framework of man-environment relationships. Her analytic framework includes interrelationships of the natural environment (physical and biological), man-built environment (socio-physical and socio-biological), and behavioral environment (psychological, social and institutional). Morrison points out that implementing computer simulation of such a model will not be possible until the behavioral dimensions are further quantified. The potential advantages of simulation in general, however, are promising.

> The merit of attempting computerization of this or any man/environment analytical framework would be in its long term use at the policy-decision-making and design-decision-making levels. As obdurate a task as computer simulation would be, it is much less a task than actual physical manipulation of men and environments to gain the needed insights for optimum decision-making surrounding man-environmental issues. (Morrison, 1975, p. 11).

Housing is an integral part of a region's economy, and the interrelationships of housing to other parts of the economy are numerous. The housing industry is often used as an economic barometer to indicate the state of the economy, and as a tool to help control economic fluctuations (Lindamood and Hanna, 1979).

Housing within a region is a complex issue. With all of the economic, social, psychological aspects of housing, it is difficult to study housing in a comprehesive manner. An economic analysis often excludes social and psychological aspects almost entirely, reducing them to "tastes" within the concept of utility maximization. Social and psychological analyses often ignore economic realities. Using simulation as a research technique allows the researcher to integrate the interdisciplinary dimensions of housing in the design and interpretation of the simulation model. The framework to be presented will provide a means for establishing an approach in housing research which must involve not only trying to anticipate the future issues of importance in housing for individuals and families, but also a rethinking and expansion of the types of research methods used. This approach involves the continuation of the more traditional ex post facto research techniques used in housing research (survey and evaluation, for example), while also examining other less used methods and their potential applications.

Of course, simulation is not without its weaknesses. Probably the biggest of these is the unreality of the simulation. That is, simulation appears to be modeling the real world, and if the user is not careful, there is a tendency to make real world assertions on the basis of the simulation. In fact, the results of the simulation depend on the assumptions of the model. These can take the form of the assumed mathematical or statistical properties of the model (linearity, for example), assumed values for the model's parameters, and/or assumed lines of causality between the model's parameters and variables.

In addition, there is the ever present constraint of inadequate data bases, especially for large scale models requiring many parameter and variable values. Surveys are often too expensive, and secondary data bases often contain disclosure problems and related problems of detail. Weak data bases reduce the model's level of detail or lead to spurious results to "what happens if..." questions.

Recognition of these weaknesses is necessary to obtaining the full value out of a simulation exercise. Attempting to overcome them, or at least make them less onerous, is the constant tast of the simulation practitioner.

<u>One Approach to Simulation using Input-Output Analysis</u>

Simulation techniques offer an empirical tool for analysis by providing a mathematically consistent mechanism. Economic input-output models are one such empirical tool.

> The input-output model is independent of political, social, and economic systems. Unlike the models of the major schools of economic thought of the past, it says nothing about how resources should be allocated and incomes distributed. It is a value-free system which can be applied in free-market, partially planned, or totally planned economies. An input-output analysis tells us nothing about what "should" be; it describes the economy as it is. Various assumptions can be made about changes in technical coefficients, in final demand, or in total gross output. Once these assumptions have been made, the system can be used to make projections regardless of whether resource allocation and income distribution are determined by market forces or executive decree. (Miernyk, 1965, p. 88-89)

Input-output, or intersectional analysis, is a widely used tool in economics that systematically examines the interdependence of various sectors in an economy through simulations. Regional models can provide empirical analyses of interregional and intraregional interactions. Interactions of various sectors of the economy are extremely complex, with direct and indirect impacts on other sectors associated with a change in any one sector. Regional models have been used in the past for simulations by economists. In Minnesota, the model used in the present study has been used extensively in Northeast Minnesota (Lichty, Flannery, and Peterson, 1982). The Minnesota model will be described in detail in the next section.

Residential housing impacts on many sectors in an economy, from construction industries to financial lending institutions. Therefore, insight may be gained from examining the relationships between demand for housing and the consequent demand for production in other sectors of the economy. Conversely, simulating changes in other sectors of the economy can be used to project demand for housing.

While dynamic modeling is possible, input-output analysis generally represents a still picture of economic relationships between producers and consumers of goods and services in an economic region. It demonstrates interaction between defined industrial sectors in terms of their sales to and purchases from one another. It also shows the complicated relationship between goods consumed and the amount and mix of goods produced in the region. A change in the consumption of the output of one firm will be reflected, for example, in changes in that firm's demand for intermediate products by other firms, as well as changes in that firm's demand for labor, capital equipment, and other resource inputs.

A change in output of one commodity, in input-output analysis, will cause changes in demand for other commodities and services until the economy achieves a new "equilibrium." Achieving equilibrium may require more than one round of outputs, since increasing or decreasing output in one sector will have secondary effects on intermediate purchases and resulting sales from other sectors.

First, input-output analysis has several weaknesses. Input-output analysis is not a statistical technique. It does not establish confidence intervals around its predictions. Rather, it provides mathematical consistency in forecasting.

Further, input-output is based on static assumptions; i.e., such factors as price changes and input substitutions resulting from such price change signals are not easily accommodated in input-output analysis. The SIMLAB model does introduce a dynamic element into the input-output system through the various modules relating to final demand. However, the system's multiplier values are held constant which represents another weakness in these types of models.

SIMLAB: An Application of Input-Output Analysis

The model used in this study is an input-output model developed at the University of Minnesota called SIMLAB. SIMLAB is a large-scale simulation laboratory model representing significant extensions of traditional input-output techniques. SIMLAB uses secondary data from a variety of sources, including census data (Bureau of the Census, 1982; Kaplan and VanValey, 1980; Minnesota Analysis and Planning System, 1982), as well as data from the Department of Labor and the Department of Commerce, and is based on the original U. S. input-output table from the Department of Commerce.

SIMLAB is capable of interactive analysis; i.e., analysis where the user is allowed to change parameters and to simulate impacts from these parameter modifications on regional economic and demographic variables. SIMLAB identifies and simulates interactions between ten potential modules. Table 1 lists these modules.

TABLE 1

The Ten Basic Modules of SIMLAB

1. Market
2. Investment
3. Demand
4. Production
5. Income
6. Employment
7. Labor Force
8. Population
9. Household
10. Recreation

The market module relates regional SIMLAB information to the rest of the nation and includes such ratios as the proportion of national output accounted for by the reference region's industries. The investment module shows the capital to output requirements for each industry as well as the proportion of local supplying industries that help meet these requirements.

The demand module reflects the final demand component of an input-output system with emphasis on regional exports. The production module is made up of the demand multipliers of an inverse (direct and indirect) matrix.

The income module links the economic performance of the regional economy to household income through appropriate income multipliers. The income module links direct and indirect income effects to given changes in the demand module through the production module.

The employment module contains employment to output ratios. The regional employment requirements of simulated changes in output can be determined from this module. This module also states requirements in terms of occupation, earnings per worker, etc. The employment module relates the production module to the labor force module.

The labor force module contains data on the sex and occupational composition of the labor force 16 years of age or older. It relates the employment module to the population module. It also contains data on commuting patterns for the region.

The population module contains data on births, deaths, and estimated migration levels. Migration is linked to the rest of SIMLAB through employment and labor force comparisons and through computations of unemployment rates. Unemployment in the region triggers outmigration; excess employment demand (relative to supply) triggers inmigration.

The household module combines the employment, labor force and population information into household categories. The housing stock and projected future housing requirements can be determined from this module.

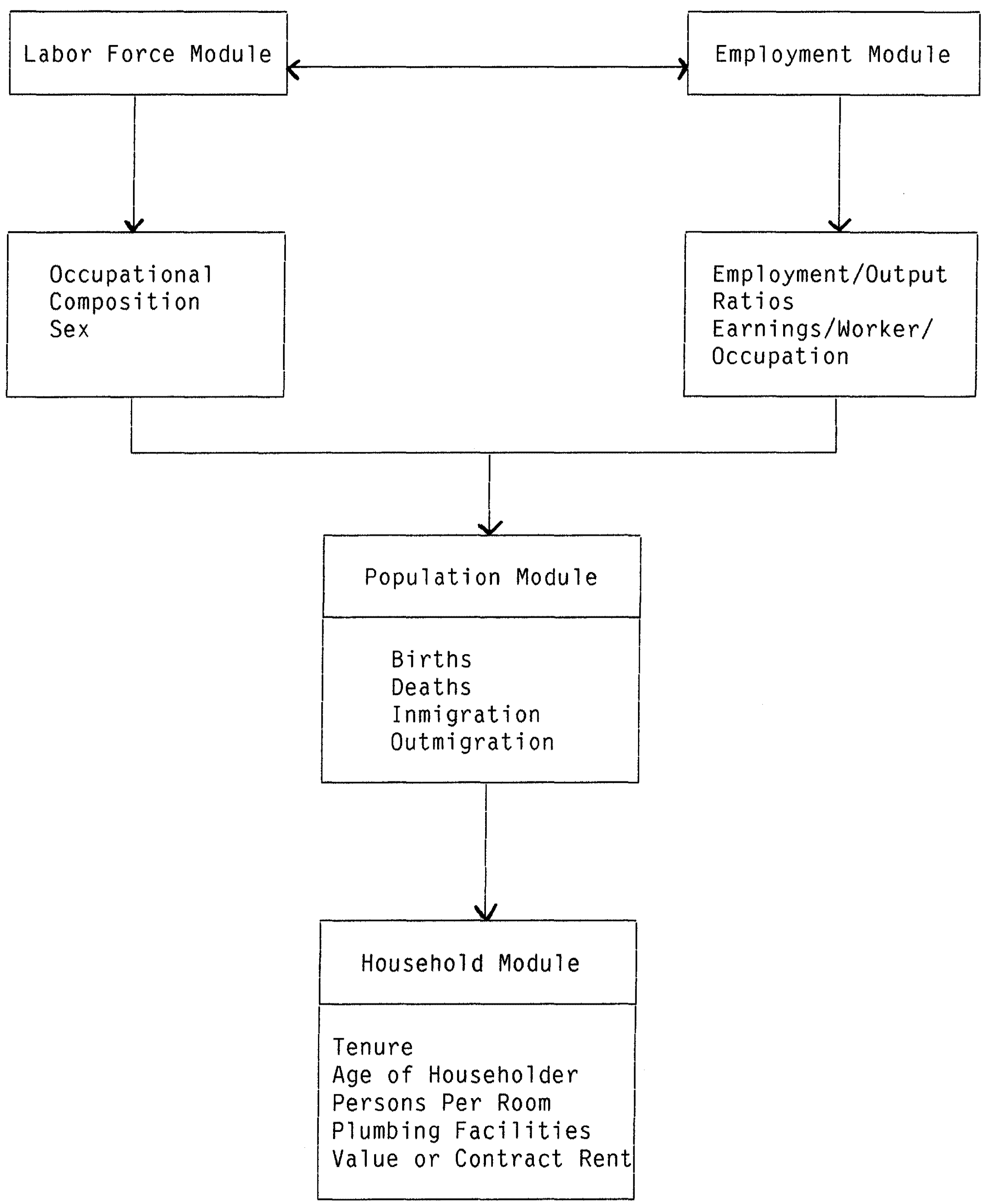
The recreation module breaks final demand into recreation and nonrecreation components. The recreation component is further broken down into a series of activity sets. These activity sets are then related to industrial output levels through final demand.

SIMLAB is a recursive model. The outputs of one module serve as inputs for the others. All of the impact accounting, however, is in a pattern in which inputs and outputs are determined simultaneously. The recursive-modular approach forces consistency in forecasting; that is, consistency in projection between modules. Output cannot expand beyond employment and capital availabilities in the region. Constraints to unlimited change are built into the system. This forces the user to explain simulated changes in one module in terms of indirect changes triggered in the remaining modules. This consistency requirement represents one of the real strengths of forecasts arrived at through SIMLAB.

The Household Module in SIMLAB

The household module in SIMLAB provides an opportunity to simulate the demand for housing due to changes in a region's economy, and therefore can serve as an important tool for local agencies and organizations in providing a consistent forecasting picture for a region. The household module is triggered by the population module in SIMLAB. The population module is triggered by the labor force and employment modules. The components of each module and the interaction path are shown in Figure 1.

FIGURE 1



The demand for owner-occupied or rental housing and the demand for various levels of housing quality are related to both the supply of different types of housing within a region, and to the demograhic characteristics of the population. Demographic variables, including age of householder, income, and inmigration and outmigration patterns, among others, are included in the household, labor force, employment, and population modules.

The data for the household module were obtained from the 1980 decennial census. County level data from selected variables in the 100 percent population and housing counts short-form were used for a seven-county region in Northeast Minnesota. Variables in the household module include age of householder, tenure form, value of owner-occupied housing units, persons per room, presence or absence of complete plumbing facilities, and contract rent for renter-occupied housing units.

A Housing Simulation: The Effects of Population Changes on Housing Within a Regional Economy

A major application for simulation models is to answer the question: "What if...?" Models such as SIMLAB can simulate responses to hypothesized changes in parameters hypothetically.

Requirements for effectively using SIMLAB include the following: (1) the researcher needs an overall knowledge of the economy to make reasonable projections; (2) the researcher must simulate plausible scenarios; and (3) the researcher must be able to make logical interpretations of inconsistencies in the results of the simulation. The broader the knowledge of the economic area under study, the better. Even with limited knowledge, however, more information is included by default in an input-output model than is included in more traditional experimental or survey designs.

In the example presented in this section, the simulation will examine the effects on housing demand (owner occupied and renter occupied) resulting from the introduction of a direct reduction processing facility into the Northeast Minnesota economy. The regional economy is currently experiencing stagnation as a result of structural changes in American steel industry. These changes have greatly reduced the demand for taconite ore, the principle export of the regional economy.

In an attempt to turn this situation around, state and regional officials are exploring the possibility of reducing the ore to an iron slab product, higher in value than the taconite pellets themselves. This iron slab product would increase the productivity of steel producing facilities in the lower Great Lakes region representing the principle customers for Northeast Minnesota ore.

The impact of such a facility on regional output, employment, and population has been analyzed as part of a normal SIMLAB run. The impacts are seen as deviations from a baseline, or, all other things being equal, as a set of assumptions. The population changes simulated in this exercise have direct impact on the number of households in the region that are owner-occupied and renter-occupied units. These changes are simulated by the age of the head of the household that results from simulated employment and population changes.

Table 2 presents the 1983 distribution of head of households among the owner occupied and renter occupied units in the region. The figures can be taken as households in each of those categories. The figures in this table are common to both the baseline and the modified run because 1983 is taken as the starting point for the simulation.

TABLE 2

Head of Household by Age
Arrowhead Region, 1983

Age	Owner	Renter	Total
15-17	13	35	48
18-19	104	746	850
20-24	3515	6086	9601
25-29	9804	5421	15224
30-34	8881	2320	11201
35-44	15187	2506	17693
45-54	14277	1666	15943
55-59	9523	1310	10833
60-64	25371	1567	11036
65-**	25371	8726	34097

Table 3 shows the same distribution for the year 1990. This is the distribution that would occur if all of the assumptions concerning the current progress of the economy hold without change. Younger households are more likely to rent than older households until the age group of 65 and over is reached. In all cases of household heads above 24 years of age, there is a greater proportion that own homes than rent them.

TABLE 3

Head of Household by Age
Arrowhead Region, 1990

Age	Owner	Renter	Total
15-17	13	36	49
18-19	76	547	624
20-24	1606	2782	4388
25-29	5804	3209	9014
30-34	11917	3112	15029
35-44	18418	3040	21458
45-54	12000	1401	13400
55-59	6109	840	6949
60-64	8741	1446	10187
65-**	29840	10263	40103

If the current trends continue, it might also be noted that there is a mixed package of growth in households when measured by the head of household distributed across the various age brackets. There is a decrease in households with the head of household from 15 to 29 years of age, then an increase in the 30 to 44 years range, followed by a decrease in the 45 to 64 years range, and a significant increase in the over 65 years category. The overall indication is one of an aging population in a stagnant economy.

Table 4 presents the same information for the year 1990 assuming the introduction of a direct reduction facility. This clearly highlights the "what happens if..." procedure alluded to in the introductory paragraph of this section. The "if" set of assumptions includes the introduction of the facility into the simulation system through an increase in the region's output, exports, employment, and earnings. The simulation then runs through the various modules that form the basis for the housing module prediction.

TABLE 4

Head of Household by Age
Arrowhead Region, 1990
With Direct Reduction

Age	Owner	Renter	Total
15-17	15	40	55
18-19	89	638	727
20-24	2117	3666	5783
25-29	8573	4740	13313
30-34	13341	3484	16825
35-44	19921	3288	23208
45-54	13056	1524	14580
55-59	6587	906	7493
60-64	9146	1513	10660
65-**	30902	10629	41531

In comparing Tables 3 and 4, it can be seen that the introduction of the direct reduction facility increases the demand for both owner occupied and renter occupied housing over what would be the case for 1990 without the facility. In fact, the model specifies the resident status by age and by ownership. While it is not shown in this particular simulation, the user of this system also has the prerogative of changing the parameters specifying the distribution of these age groups among the two categories for a second level set of simulation questions.

However, in comparing Tables 2 and 4, it can be seen that the introduction of such a facility does not completely turn around the decline in housing demand for certain age categories. While there are some changes, particularly in the extent of decline for housing by the lower and middle age categories, the primary effect is to lower the rate of decline in demand for housing by the younger age categories. For example, without direct reduction, there is a 48 percent decline in the demand for housing by the 20 to 24 years group between 1983 and 1990. With direct reduction, the decline is 40 percent. This represents a significant relative improvement in housing demand with direct reduction.

Future Development of the Model

Also not shown, and currently not included in the module, are two important additions to the system that will represent the next step in the research design. The first is a system of housing capacity indicators that would relate the demand for housing forecasts to housing supply. The programming for such a system is completed and data are being secured for inclusion in that program.

Once housing demand and housing supply are linked in the system, housing investment analysis will be possible based on the relationship between such demand and supply. This will provide a feedback system that allows changes in exports to create changes in housing demand, and changes in housing demand leading to new construction activity, resulting in new changes in housing demand, and so on until the effects of such an export change are fully distributed through the system. While such a feedback loop has not been programmed for the system, it is conceptualized and may be introduced with only minor additional programming requirements.

Finally, every system has its set of assumptions. SIMLAB assumes that housing demand is a function of the relationship between employment, population, and the performance of a regional economy relative to changing industrial outputs. This demand comes out of a recursive system based on input-output techniques referred to earlier. As such, changing prices are not allowed in the system, and that includes prices related to the housing units themselves. The term "housing demand" has a very specific reference in this regard and does not constitute the usual price oriented demand function.

Likewise, supply relates to the investment process, although changing incomes can be taken into account through the introduction of appropriate income elasticities of demand for housing relative to appropriate supplies of stated quality housing units. Again, such analytical possibilities are capable of being introduced into the system, but at present there is no conceptualized or programmed component to take such interaction into account.

Summary

What this paper reports is a very important first step (and perhaps even a small second step in programming) towards the implementation of a full scale, recursive household module in the SIMLAB system. It establishes the basis for the construction of housing demand within the system and the programming for housing supply. It allows the simulation of changing household characteristics related to such housing demand on an owner occupied and renter occupied basis. The programming is completed for the introduciton of rates of change in these latter characteristics as well. Useful information comes out of simulation exercises using the system as it is, a demand based projection of the effects on households from changes in an economy. Once the additional steps are taken, the demand and supply/investment relationship will be capable of analysis as well.

The use of computer simulation in housing research offers the following advantages:

1. Simulations provide an organizing mechanism for studying the complexity of housing interactions in a regional economy.

2. Simulations offer the ability to imply possible effects of specified scenarios and decisions without actually implementing them.
3. Simulation techniques offer the methodological advantage of combining system control with the use of "real world" data.

In addition to the general advantages of simulation, there are practical benefits to housing education, private and public sector applications, and consumers from using the SIMLAB model. Currently, a smaller version of SIMLAB is being designed for classroom use. The model will be used in post-secondary housing and economics classes. It is hoped that using the model will enable students to better understand the interdisciplinary dimensions of housing, as well as the complexity of the issues.

Using models like SIMLAB to facilitate decision-making in the private and public sectors can increase the ability to see possible effects of policy and market decisions without actually implementing them. Historically, the balance between population and housing stock has not been made. Adaptations often occur at the expense of the consumer. With simulations, demographic projections could be used much more effectively in the housing market than they have in the past.

Looking at existing housing stock, inmigration and outmigration patterns, and the age of the population can aid planners in making decisions about what housing policies are best suited to an area. The simulation may be used as a tool to justify monetary requests for housing programs, an especially critical use as competition for funds becomes more fierce. Simulations can also be used in the private sector by financial institutions and construction industries in determining the need for various housing structure types and tenure forms.

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