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# *USING ECONOMIC SIMULATION TECHNIQUES IN HOUSING ANALYSIS*

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## *ABSTRACT*

*This paper describes a framework for analyzing housing as it relates to a regional economy. The framework is represented by a large scale, input-output based simulation model developed at the University of Minnesota, St. Paul. A housing component to that model was recently added and is described in this paper. This paper also views input-output and simulation as techniques for analysis. It highlights the advantages of such approaches to housing research and provides a sample simulation run to demonstrate the model. The model looks at population change over time through the use of a population module. The population module relates such change to the economic performance of the economy taken from the system's production module. The simulated change in population is then related to the changing demand for housing structures given existing demand and parameter values out of the housing module. Various assumptions concerning the economy's performance are made with simulated changes in housing demand as the output.*

## *INTRODUCTION*

Housing has been examined from many perspectives---sociological, psychological, historical and economic. This paper introduces a framework for looking at housing as it relates to a regional economy. It explores the use of computer simulation in housing analysis.

The objectives of this paper are to: 1) describe the significance and potential contributions of 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 future applications of the model.

### *Importance of Simulation Techniques in Housing Analysis*

The potential for simulation modeling in social science research is emerging as an alternative style of research in social science methodology literature (Chen, 1983). Babbie (1975) says that

> 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

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> 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 (p. 290-291).

The advent of large-scale computers capable of complex calculations increased the interest in simulation models. Emory (1980) states that in a methodological content "simulation may be described as the process of conducting experiments on a model of a system" (p. 354).

Morrison (1975) proposes that computer simulation be applied to an analytic framework of man-environment relationships. Her framework includes interrelationships of the natural environment (physical and biological), 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 is not possible until the behavioral dimensions are further quantified. The potential advantages of simulation, however, are promising. According to Morrison,

> 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. (p.11).

Housing is an integral part of a region's economy. The housing industry is frequently an economic barometer indicating the state of the economy and helping to control economic fluctuations (Lindamood and Hanna, 1979). Housing within a region is a complex issue. With all the economic and psychological aspects of housing, it is difficult to study housing in a comprehensive manner. An economic analysis often excludes social and psychological aspects, 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 in this study provides an approach to housing research that involves the anticipation of important issues in housing for individuals and families. It also offers a rethinking and expansion of the types of research methods used. It involves the continuation of the more traditional *ex post facto* research techniques used in housing research (survey and evaluation, for example), while examining other less used methods and their potential applications.

Simulation is not without its weaknesses. The biggest of these flaws is the unreality of the simulation. That is, simulation appears to be modeling the real world. 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.

There is also 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 answers to "what happens if ..." questions.

Recognition of these weaknesses is necessary to obtaining the full value of a simulation exercise. Attempting to overcome them is the constant task of the simulation practitioner.

*One Approach To Simulation Using Output Analysis*

Simulation techniques offer an empirical tool of analysis by providing a mathematically consistent mechanism. Economic input-output models are one such empirical tool. Miernyk (1965) states that

> 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 that 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 (p. 88-89).

Input-output, or intersectoral 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 inter-regional and intra-regional 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. Economists in the past have used regional models for simulation. The model used in the present study has been used extensively in northeast Minnesota (Lichty, Flannery, and Peterson, 1982). The Minnesota model is detailed in the next section.

Housing affects many sectors of the economy--from construction industries to financial lending institutions. Insight may be gained, therefore, 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.

## *SIMLAB: AN APPLICATION OF INPUT-OUTPUT ANALYSIS*

The model used in this study is an input-output model called SIMLAB, developed at the University of Minnesota. 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. SIMLAB is based on the original United States input-output table from the Department of Commerce.

SIMLAB is capable of interactive analysis. Interactive analysis allows the user 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 compares 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. It 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. It 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 out-migration; excess employment demand (relative to supply) triggers in-migration.

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 non-recreation 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 the 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. It can serve as an important tool for local agencies and organizations in providing a consistent forecast 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.

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 demographic characteristics of the population. Demographic variables, such as age of the household head, income and in-migration and out-migration patterns, are included in the household, labor force, employment and population modules.

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

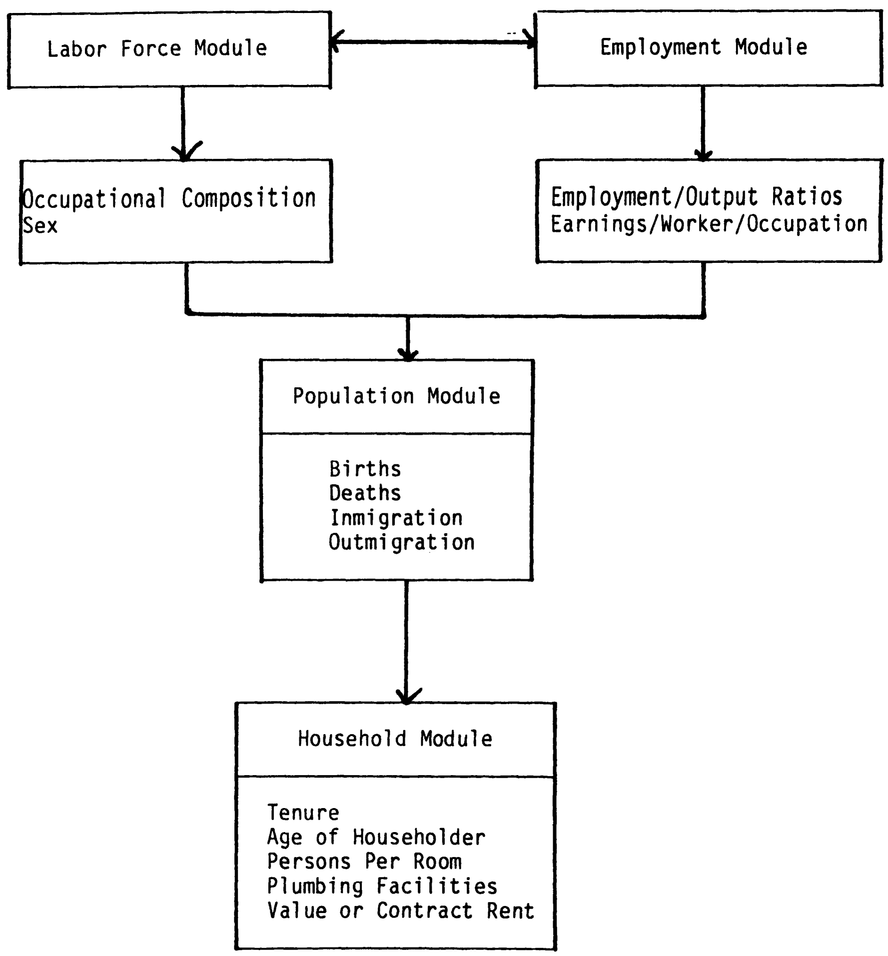
## *A HOUSING SIMULATION: THE EFFECTS OF POPULATION CHANGES ON HOUSING*

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 examines 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 there is currently experiencing stagnation as a

FIGURE 1



Labor Force Module
Employment Module
Occupational Composition
Sex
Employment/Output Ratios
Earnings/Worker/Occupation
Population Module
Births
Deaths
Inmigration
Outmigration
Household Module
Tenure
Age of Householder
Persons Per Room
Plumbing Facilities
Value or Contract Rent

result of structural changes in the American steel industry. These changes have greatly reduced the demand for taconite ore, the principal export of the region.

In an attempt to reverse this situation, 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 plants in the lower Great Lakes region, which represents the principal 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 as a set of assumptions. The population changes simulated in this exercise affect the number of households in the region that are owner-occupied and renter-occupied units. These changes are simulated by the age of the household head resulting 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 these categories. The figures in Table 2 are common to both the baseline and the modified run because 1983 is taken as the starting point for the simulation.

Table 3 shows the same distribution for 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 are 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 who own homes than rent them.

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 | 15225 |
| 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 |

If the current trends continue, 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. There is a significant increase in the over-65 years category. The overall indication is one

Table 3. Head of Household by Age ---Arrowhead Region, 1990

| Age | Owner | Renter | Total |
|---|---|---|---|
| 15-17 | 13 | 36 | 49 |
| 18-19 | 76 | 547 | 623 |
| 20-24 | 1606 | 2782 | 4388 |
| 25-29 | 5804 | 3209 | 9014 |
| 30-34 | 11917 | 3112 | 15029 |
| 35-44 | 18418 | 3040 | 21458 |
| 45-54 | 12000 | 1401 | 13401 |
| 55-59 | 6109 | 840 | 6949 |
| 60-64 | 8741 | 1446 | 10187 |
| 65+ | 29840 | 10263 | 40103 |

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. The "if" set of assumptions included 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 | 14508 |
| 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 is is not shown in this particular simulation, the user of this system 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.

In comparing Tables 2 and 4, it can be seen that the introduction of such a facility does not completely reverse 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 of age group between 1983 and 1990. With direct reduction, the decline is 40 percent. This represents a 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 represent the next step in the research design. The first addition 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 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 creating new construction activity. New construction activity would result 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 sets 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. 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. Changing incomes can be taken into account, however, 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. At present, however, there is no conceptualized or programmed component to take such interaction into account.

## *SUMMARY*

What this paper reports is a first step 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 introduction of rates of change in these latter characteristics as well. Useful information is produced by simulation exercises using the system as it is--a demand-based projection of the effects of households from changes in an economy. Once 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 potential 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, to private and public sector applications, and to consumers 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 students, using the model, will 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.

Analyzing existing housing stock, in-migration and out-migration patterns and the age of the population can aid planners in making housing-policy decisions best suited for a particular area. The simulation may be used as a tool to justify monetary requests for housing programs---a 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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