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# Decision Models for Housing and Community Development

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## **Decision Models for Housing and Community Development**

Decision sciences, also referred to as operations research/management science (OR/MS), is dedicated to modeling and analysis to improve operations management and policy design. OR/MS topics are not ordinarily a part of the training that housing and community development professionals receive. However, housing and community development problems are often multifaceted, technically demanding and require action in the face of limited information and/or resources. They address operational concerns such as location, tenure type, size, development cost, timing and financing, and policy concerns such as programmatic focus, service type, social impacts, strategy design, perceptions of fairness and social, environmental and economic sustainability. Problem solutions must address the needs and preferences of multiple stakeholders, uncertainty regarding problem data and decision alternatives, multiple analytic methods and varying units of analysis. These problems, in the words of Saul Gass, are ‘wicked’. In these cases, decision models may provide insights that are unavailable using conventional analytic methods.

In particular, decision models allow analysts to quantify diverse impacts and constraints related to housing and community development; to develop deeper understandings regarding tradeoffs associated with multiple goals or objectives, and to identify alternative policies and specific courses of action. Decision models may incorporate qualitative methods such as value-focused thinking and problem-structuring methods, quantitative methods such as mathematical programming and stochastic modeling, as well as mixed-method approaches that incorporate aspects of community planning.

The literature on decision models and methods related to housing and community development is long-lived, multi-disciplinary and broadly-conceived, from very stylized models of real-world

systems mostly relevant to scholars, to computer-based applications intended to assist practitioners. This literature may be divided into three areas: ‘descriptive models’ that provide theory, abstracted representations and data regarding policies, systems and phenomena, ‘prescriptive models’ that generate specific recommendations for action that are best, or optimal, and ‘decision support systems’ that automate the process of generating data, solving models and displaying results.

In the sections that follow, we discuss descriptive and prescriptive models and decision support systems in land-use planning, affordable market-rate housing, subsidized housing, environmental sustainability, commercial development and foreclosed housing. We conclude by describing a research agenda for decision models in housing and community development.

### **Descriptive Models**

Public-sector applications of OR/MS must balance verisimilitude, tractability and policy relevance. Descriptive research is crucial for establishing the validity of policy prescriptions and potential utility of end-user applications. Retrospective analysis focus on understanding phenomena using historical data, or synthesize previous work; prospective analysis includes simulations of various kinds to anticipate future states.

### **Retrospective Analyses**

The American Housing Survey has been used to estimate the likelihood of homeownership as a function of a variety of affordable lending policies and to demonstrate that regulations that restrict the supply of newly-constructed, market-rate housing can reduce the size of affordable housing stock. Variations in economic relationships between private developers and public

housing managers, and physical configurations of subsidized and market-rate housing are shown to have impacts on regional housing markets in the U.S.

Recent examples of evaluations of subsidized and mixed-income housing include reviews of the ambivalent and sometimes contradictory findings of evaluations of large-scale U.S. initiatives to redevelop large-scale public housing communities (HOPE VI) and to provide housing vouchers combined with mobility counseling to enable low-income families to access ‘geographies of opportunity’ in central cities and nearby suburbs in the U.S. (Moving to Opportunity and the Gautreaux Program). A survey of current trends in transit-friendly, mixed-use development and redevelopment of distressed inner-city neighborhoods into mixed-income communities advocates for public-private partnerships.

In Australia, the presence of low- and moderate-income families in low-density suburbs that lack certain amenities such as transit access is not in itself evidence of ‘locational disadvantage’ justifying social interventions; the role of individual social status and locational decisions balancing multiple criteria must be considered as well. Analysis of production levels of social (subsidized) housing in Ontario was used to determine whether individual planning areas were receiving their “fair share” of social housing. A historical survey of U.S. low-income housing policy concluded that that mixed-income, housing dispersion or housing mobility strategies, alone, are unlikely to address the underlying policy goal of socioeconomic integration.

A life-cycle analysis of market-rate housing using a stocks-and-flows-based model has allowed evaluation of the benefits and costs of different housing construction and maintenance practices. Observations of homes advertised for sale can help identify clusters of housing with shared attributes, as well as key physical determinants of housing choice.

The recent foreclosed housing crisis in the U.S. has spawned a variety of research on foreclosed housing impacts on individuals and communities. There is a consensus that foreclosed units have some detrimental discounting effect on nearby properties, but that these effects are generally around small and apply only to properties within a short distance of a foreclosed property. These impacts vary according to stage of foreclosure process a distressed unit resides, whether a neighborhood is urban or suburban, and the strength of the local market. Foreclosed housing has also been shown to increase the incidence of violent crimes.

### **Prospective Analyses**

Surveys and focus groups have been conducted of residents in affordable housing to build and validate a neural network model of residential satisfaction. Analytic simulation models based on economics principles demonstrate that housing mobility programs have the potential to decrease regional-level well-being even if they achieve their programmatic goals. Observations of individual housing units may be used to compute survivor functions that estimate the remaining useful life of classes of units; this method is used to recommend alternative national-level policies for renovation of the public housing stock.

Land-use planning and sustainable development are especially well-suited for prospective descriptive models since the future impacts of policies in these areas are highly uncertain. The relationship of an individual housing unit to its environment is used to define measures of environmental sustainability, and thus to measure sustainability impacts of housing-level performance targets. Systems dynamics models can identify variables to model the social, economic and environmental sustainability of housing and community development. A critical review of conceptual models and planning frameworks for sustainable affordable housing results in a proposal for a new approach that addresses different development phases, is cross-

disciplinary and involves multiple experts and stakeholders. Agent-based models may be used to simulate the spatial impacts of residential location on urban sprawl. A proposed research agenda for social development—including housing—lies at the intersection of systems analysis, sustainable development and OR/MS.

### **Prescriptive Models and Decision Support Systems**

The scholarly OR/MS literature contains many models of housing and community development intended to generate specific policies and recommendations.

#### **Land Use Planning**

A stylized modeling approach to land use planning optimizes social surplus associated with generalized planning alternatives, in which no reference is made to the geography of regions, nor of specific uses. Another approach solves a multi-objective model on a grid to optimize compactness and acquisition and development cost as well as land area, and proximity to high- and low-amenity communities and compactness.

Most decision modeling applications for land-planning are rooted more closely in specific planning policies and/or realistic representations of the environment. One such application contributes to the design of fair housing policy using a linear programming model to allocate low-income households to zones in order to minimize total commuting and housing costs; another contributes to urban renewal programs by assigning specific building types, levels and prices to land parcels to optimize net social benefit. Paying even closer attention to geography and real-life stakeholders, a multi-objective decision model for “smart growth” incorporates the values of a government planner, an environmentalist, a conservationist and a land developer and uses actual, non-uniform land parcels to generate a range of alternative strategies. Computerized

spatial decision support systems (SDSS) that automate land-use planning and development systems may incorporate optimization models such as the ones listed above, but are less often focused on specific housing-related decisions.

### **Affordable and Subsidized Housing**

Formula-based allocations and a gravity model have been used to generate allocations of affordable housing across a large study area; another model assigns production levels for affordable housing to minimize total costs while accounting for environmental impacts and construction technology requirements; a third chooses locations for affordable housing to optimize social efficiency and equity measures.

Subsidized housing and military housing is a popular choice for decision modeling, since government planning is central to program design. An optimal control model of a generic housing mobility initiative is used to identify stable and unstable long-term equilibria associated with different housing mobility policies. Decision support systems for housing mobility counseling have been designed to reflect the needs of housing clients, counselors and landlords. Multiobjective decision models for conventional rental housing voucher programs generate alternative potential allocations of program participants to Census tracts across a county to balance net social benefit and equity. Models for project-based housing are more likely to address specific issues of logistics and operations. A multiobjective model for location of project-based subsidized rental housing optimizes social efficiency and equity measures. An adaptation of production scheduling problems generates policies for relocating families in public housing communities undergoing renovations to minimize total development time and tenant disruption. Queueing theory is used to evaluate the impacts of alternative public housing tenant

assignment policies. Decision support systems assist the U.S. Army in forecasting demand and allocating resources for military housing.

### **Market-Rate Housing and Foreclosures**

The Analytic Hierarchy Process is used to quantify and assess priorities of customer requirements for industrialized housing. A spatial DSS supports property management and sales, as well as identification of potential properties for purchase. A multi-objective discrete math programming model under certainty designs strategies for foreclosed housing acquisition and redevelopment. Dynamic and stochastic programming models may be used to manage portfolios of foreclosed housing, accounting for uncertain market conditions.

### **Research Agenda**

There are a number of promising research opportunities in decision modeling for housing and community development. Descriptive models such as systems models of affordable housing and community development could be extended to incorporate multiple transitions over space, class and time associated with policy interventions such as particular assisted housing programs but also normal class and household mobility. Current research on agent-based models for residential location could address affordable and subsidized housing development. Prescriptive models could generate strategies for collaboration across jurisdictional boundaries, service categories and client populations, adapt results on social impacts of housing into more realistic objective functions, and investigate the relationship between qualitative models for values design and problem structuring and quantitative models to generate specific action steps. Advances in spatial decision support systems could reduce technical barriers to use, incorporate detailed housing market and community-level data, allow users to identify and rank decision alternatives with a variety of methods, and facilitate collaboration between multiple stakeholders.



## Conclusion

The research literature in the area of decision modeling for housing and community development is large, diverse and long-lived. It incorporates descriptive research delineating real-world systems and phenomena, prescriptive research to design strategy and operations, and computerized applications to automate analysis and decision-making. There are substantial opportunities for research that crosses disciplines, develops novel theory and generates real-world applications.

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*See also*

Affordability, Public Housing, Residential Mobility, Smart Growth, Urban Redevelopment

## Further Readings

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