Real Estate Problem Solving and Geographic Information Systems: A Stage Model of Reasoning

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Abstract

The development of computerized geographic information systems (GIS) and the accompanying extensive databases, many of them utilizing desktop computers, has created a technological revolution extending directly into real estate problem solving. Real estate problems are often characterized as uncertain, complex, and dynamic. Solving them, if solutions are possible, is a multistep process with a strong emphasis on deductive reasoning and decision making, both emphases adopted from the finance and economics disciplines. This article develops a stage model that considers the fundamental reasoning activities of description, explanation, prediction, judgment, and implementation common to all problem-solving steps in order to assess how GIS may affect real estate problem solving. The model is used to demonstrate the potential of GIS to more fully incorporate problem-solving steps other than decision making into the problem-solving process and to make inductive thinking more rigorous and accessible. The article also considers the issues of rigor and relevance and potential side effects and unintended consequences associated with the use of GIS or other information technology.

Introduction

The joining of computers and geographic information systems (GIS) has created a technological revolution that has, in turn, triggered an intellectual revolution extending beyond the traditional boundaries of geography directly into real estate. Real estate analysts now have access to user-friendly, data-rich, inexpensive GIS packages capable of importing files from popular database products and from other information technologies, such as the World Wide Web. These GIS packages and available data enable real estate analysts to perform complicated spatial analyses, including the preparation of all varieties of maps, easily and in minutes, in sharp contrast to the hours, days, and weeks that such analyses required before desktop GIS technology was available.

The importance of the spatial component that puts the geographic in GIS can hardly be overemphasized in real estate where an accepted mantra is “location, location, location.” While those in real estate are quick to point out that location, while critical, is only one of many factors to be considered, it is the spatial component that in many important ways distinguishes real estate as a field of study and individual properties from one another. In this context, real estate analysts must frequently function as applied geographers, whether they do so implicitly or explicitly. Because of the ease of performing spatial analyses with GIS, the technology may convert more real estate analysts into real estate geographers explicitly considering the spatial component more rigorously than before.

Driving real estate geographers’ interest in GIS is the belief that it has analytical capabilities to solve problems more effectively than alternative approaches. Those in real estate will make the necessary investment of money, time, and cognitive energy, all in short supply, if the perceived benefits exceed the perceived costs. However, estimating the costs and benefits is not easy. On the cost side, certain hard-dollar expenditures related to
software and hardware are relatively easy to estimate. The softer costs of time, consulting fees, and aggravation are more difficult but can be estimated with a reasonable amount of thought. However, estimating the potential benefits from GIS in terms of improved decision making may present a greater challenge, especially to those not familiar with GIS or geography.

This article considers how GIS may affect real estate problem solving. Its underlying assumption is that the appropriate measure of the value of GIS, or any information technology, is its ability to improve problem-solving capabilities in a cost-effective manner. Problem solving may be viewed as a series of stages with a common set of more elemental reasoning stages associated with each stage. This article concentrates on the more elemental reasoning stages common to all problem-solving activities. In particular, a five-stage model of geographic reasoning is developed, and the ability of GIS to assist each is considered. Accordingly, this article focuses on the general nature of geographic reasoning and is a blend of philosophy and practicality. The stage model presented here is not limited to GIS; it may be used to evaluate the potential impact of other information technologies, such as the World Wide Web, on problem solving as well (Rodriguez, Lipscomb, and Yancy, 1996; Thrall, forthcoming).

While GIS is shown to have the potential to aid all stages of reasoning, it is not portrayed as a panacea. Any benefits to individual GIS users will vary substantially, depending on the problems to be solved, the extent to which GIS is capable of assisting in solving them, and the ability of the user to utilize GIS with skill and creativity. Like other information technology—spreadsheets and general purpose databases, for example—the full value of GIS is not in the software itself but in its skillful and creative use in the identification of appropriate problems and the solution of those problems. The article also considers selected philosophical issues surrounding the use of GIS and virtually any other information technology.

So, one of our goals is to offer a perspective on how real estate information technology in general will change our disciplinary outlook. In particular, GIS technology, which receives our greater attention here, offers an accessible spatial dimension. Other technologies, such as the World Wide Web and other electronic communications capabilities, offer speedy diffusion and more timely access to information across the globe. We believe that the GIS component has the potential to change our perception of our discipline and our analytical approach. In combination with other information technologies, GIS has the potential to change the manner in which real estate is practiced.

**Real estate problems, problem solving, and GIS: An overview**

*The spatial element*

Real estate problems come in all shapes and sizes, ranging from deciding whether to repaint the laundry room in an apartment complex to determining the number of square feet of office space and how many buildings it should be spread over in a large mixed-use development. Some problems are purely finance-oriented, while others are purely personnel problems. However, many of the problems that are considered to be uniquely real estate in nature directly or indirectly involve spatial, or geographic, components in which the relationships between the subject site or property and other properties, space users, and customers are of fundamental importance.

Spatial relationships are fundamental because they affect the rent generating potential of a given site. In some instances, the problem is one of selecting the best location for a particular use—a fast-food franchise or quick lube operation, for example—while in other
instances the problem is one of finding the optimum use and the intensity of that use for a particular site. Whatever the nature of the problem, the essential issue frequently becomes the forecasting of income streams associated with different uses and intensities over time as the starting point for financial evaluations. Given the importance of spatial analysis, both the general nature of real estate problems and the nature of traditional real estate analysis that spatial analysis complements merit brief examination in order to develop a context for examining spatial analysis in more detail.

Basic nature of real estate problems

It is tempting to say simply that real estate problems are “difficult” or “complicated” and leave it at that. However, in order to assess the benefits of GIS within the context of improving real estate problem solving, it is helpful to look at real estate problems in greater detail. When real estate problems are described, the dimensions of complexity, dynamism, and state of knowledge are frequently used. Problems may be simple or complex, static or changing every minute, certain or ambiguous, or anywhere in between these extremes. Many real estate problems have been characterized as possessing high levels of complexity, dynamism, and uncertainty (Pyhrr, 1973). In this characterization, real estate problem solvers must solve complicated, changing problems whose variables, the values of those variables, and the relationships between them are uncertain, or even ambiguous. Needless to say, outcomes are not known with certainty.

Complex real estate problems, like many others, generally are not solved in a single step but rather in a process approach involving a number of stages. Commonly noted stages include problem identification, problem representation, option generation, option evaluation, and decision making. The dimensions identified earlier—the level of complexity, dynamism, and uncertainty—may vary in degree from one stage to another depending on the problem. For example, some problems are very complex and ambiguous at the outset, but once the problem is identified and framed, developing options and choosing a solution may be quite straightforward. Other problems may be easier to frame or represent but have more complexity, dynamism, and uncertainty associated with generating and evaluating options. Because of this variation between stages, it is often difficult to assess the overall difficulty of a problem.

To better picture the impact of these dimensions on problem solving, consider Figure 1, which illustrates a typology showing how solvable problems with varying states of knowledge may be classified. Though developed to classify urban planning problems, it is equally applicable to real estate problems. In Figure 1, states of knowledge range from certainty to ambiguity, and the problem-solving process is broken into three categories: problem identification and formulation, option generation and evaluation, and option selection and implementation. Similar figures could be developed with levels of dynamism and complexity in place of states of knowledge in order to produce a more complete problem typology.

The resistance of a problem to solution is a function of the level of each of the three dimensions and, of course, their combined effects. Not surprisingly, many real estate problems possessing high levels of these three attributes are quite difficult to solve and, as in Figure 1, fall outside the types of problems amenable to solution using standard techniques. These standard solution techniques work satisfactorily with well-defined problems possessing relatively low levels of complexity, uncertainty, and dynamism but are inadequate for others. Real estate problems falling outside the domain of standard solution techniques transcend the simple term problem and may be better described as metaprob-
these problems are not solved in the strict sense of the word but rather resolved (Hart, 1986). Along with an overall resistance to solution, these problems contain another potential danger for the problem solver—even attempting to solve them may generate second- and third-order issues over time. In some problem situations the goal becomes to simply not make things any worse (Hart, 1986).

Frequently, in traditional approaches to real estate problem solving a problem is bent and shaped until it fits an existing solution technique instead of adapting the problem-solving approach to the problem. That is, many problems are treated as though they belong in the upper portion of the typology when they actually belong in the lower portion. Unfortunately, the "tool in search of a use" approach may dominate problem-solving efforts. Under such conditions, problem-solving efforts produce solutions that are wrong, but precisely so!

Real estate problem solving: The traditional paradigm

Given the difficult nature of real estate problems and the danger of the "tool in search of a use" syndrome, is there a generally accepted, comprehensive approach to real estate problem solving? The answer to this question is a qualified yes. There is a generally accepted problem solving approach, or paradigm, but it is not particularly comprehensive. The dominant paradigm focuses on decision making and how individuals should make decisions. Relating this to the three stages of problem-solving activity in Figure 1, much
of the research and teaching efforts in real estate problem solving have focused on the last stage dealing with option selection and implementation. Even though this stage includes implementation, the implementation portion has received little attention. This situation is not unique to real estate. Problem-solving efforts in general have focused on decision making. Simon (1992) contends that problem-solving elements such as agenda setting, developing representations or framing the problem, and developing solution options have received significantly less attention than the decision-making element. Efforts to develop more inclusive real estate problem-solving approaches in the form of multistep procedural models have been made by Jaffe and Sirmans (1995) and Pyhrr et al. (1989) in real estate investment textbooks. These procedural models expand the scope of consideration to include all the problem-solving stages discussed earlier. However, in teaching and research, more detailed attention generally is paid to decision making than to the other problem-solving stages.

One of the reasons more attention is given to decision making is that a richer theoretical foundation exists for it than for the other problem-solving stages. One of the results of real estate's close affiliation with finance over the last thirty years is the acceptance and use of rational choice theory (RCT) as a normative model of human choice. Finance, in turn, borrowed RCT from economics theory. RCT has rationality and expected utility as its linchpins and provides a deductive, axiom-based approach to decision making that assumes that decision makers are capable of making the correct expected utility decision if given appropriate information. It is important to recognize that RCT is a decision-making framework and that decision making is only a part of a complete problem-solving framework.

To summarize, traditional real estate problem-solving efforts generally

1. Concentrate on decision making,
2. Utilize RCT as the normative model for human choice, and
3. Concentrate on the deductive reasoning approach associated with RCT.

Having noted these characteristics of traditional real estate problem-solving efforts, this article considers how the real estate problem-solving process can be expanded to stages of problem solving other than decision making and reasoning can be expanded to include inductive, as well as deductive, processes.

Expanding the problem-solving process is not especially critical for problems that are simple, static, and certain—that is, problems that are well defined and amenable to traditional solution techniques. Because many interesting real estate problems cannot be so described, expanding the problem-solving process may be helpful. When the problem-solving process is expanded, inductive reasoning is particularly important because it is in the earlier stages such as agenda setting, framing, and option generation that essentially inductive creative processes can be most valuable.

GIS and real estate problem solving

GIS provides a mechanism for expanding the problem-solving process and for incorporating inductive reasoning. The promise and peril of inductive reasoning in real estate are outlined by Clapp, Goldberg, and Myers (1994):

The inductive mode is more conducive to problem solving. The early founder of urban land economics, Richard T. Ely, held the motto: “Look and see.” Given a real world problem, the researcher would collect data around the problem and then provide a
diagnosis. The major fault here is simple: How do we know what data to collect or how to interpret it? Some problem inquiries may be obvious (such as the characteristics of borrowers, loan terms, and markets for explaining defaulted mortgages). Other problems may be much harder to define, and no two researchers may approach inquiries in the same way. The inductive approach has the danger of being ad hoc and unsystematic.

As is discussed later in this article, there are a number of approaches to minimizing these dangers. While not a panacea, GIS provides information and analytical capabilities that may be helpful in many stages of problem solving and provide a more structured and systematic approach to inductive reasoning.

A stage model of reasoning for problem solving

In Figure 1, all the possible activities comprising problem solving are condensed into three stages: problem identification and formulation, option generation and evaluation, and option selection and implementation. These problem-solving stages have associated with them a common set of more elemental reasoning activities: describing, explaining, predicting, judging, and implementing. These more elemental cognitive activities are critical to successfully performing the tasks associated with each problem-solving stage. Depending on the problem, each problem-solving stage will rely on each elemental cognitive activity to a greater or lesser degree. By focusing attention on these more elemental activities of problem solving that occur in every stage of problem solving, a better understanding of how GIS, or any technology, can or cannot aid problem solving may be developed.

In this article these elemental cognitive activities are organized into a stage model, similar in spirit to the stage model of problem solving presented in Figure 1, in order to explore the general nature of each cognitive element, or stage, and the weak ordering of the reasoning stages. The stage model offers a framework for evaluating the ability of other disciplines, technologies, and methodologies to improve problem solving by examining their impact on fundamental cognitive elements. The stage model of reasoning (SMR) contained in Figure 2 has five stages corresponding to the elemental cognitive activities discussed earlier (Thrall, 1995). Associated with each stage in Figure 2 is a basic question that stage seeks to answer. These basic questions concern what is, why it is, what is likely, what is desired, and which possible solution is preferred, and, once chosen, how the chosen solution and the GIS system itself are implemented and monitored.

Certainly, the SMR is not considered the ultimate taxonomy. Like all taxonomies and stage models, it may be argued that its delineation of stages is somewhat arbitrary. For example, some stages may be broken into two or more stages without too much difficulty. These arguments are valid. In developing the SMR, a desire to balance detail and parsimony resulted in a model with the minimum stages necessary to capture the processes underlying real estate problem solving and to provide insights into how GIS may affect real estate problem solving.

Likewise, it should be noted that not every problem will utilize all the stages of the SMR. For example, the problem of assessing the supply of a particular type of apartment unit generally may be solved by description alone. Also, because many problems are factored into a number of smaller problems, some stages of the SMR may be repeated several times in solving a given problem.
Stage Basic Question

<table>
<thead>
<tr>
<th>Stage</th>
<th>Basic Question</th>
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<tbody>
<tr>
<td>Description</td>
<td>What is?</td>
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<tr>
<td>Explanation</td>
<td>Why?</td>
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<tr>
<td>Prediction</td>
<td>What is Likely?</td>
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<tr>
<td>Judgment</td>
<td>What is desired?</td>
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<tr>
<td>Implementation</td>
<td>How Operationalized?</td>
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Figure 2. A stage model of reasoning.

Stage one: Description

Much GIS analysis focuses on describing and representing spatially distributed phenomena on a map. Examples include describing the quantity and spatial distribution of office space, retail space, demographics, and other phenomena. Geographer Emilio Casetti (1993) suggests that "the scientific knowledge of any facet of reality starts with descriptions and inventories of facts, observations, measurements, and with explanations based on narratives." Surveying may be considered an extreme case of geography as legal description. GIS practitioners are generally concerned with the descriptions of phenomena that lie above, below, or within these survey lines. Description is an important element in many problem solving efforts.

GIS: A technology for description

GIS is a technology for geographic description—a technology tool for the display of geographical information and a vehicle for creative data visualization. It is also offers efficiency gains by making it easier to summarize large volumes of data and, thereby, new, higher levels of productivity. For example, data descriptive analyses, such as evaluating and describing the spatial pattern of property-assessment quality, required months in the 1970s but now can be completed in a few hours (Thrall 1979, 1993b). Powerful data visualization coupled with higher productivity has brought about a new way of approaching geographic problems. The technology truly gives the data voice and facilitates its exploration affording opportunities for experimentation, hypothesis development, and hypothesis testing that less efficient techniques simply do not allow.
In interpreting descriptive data, the visual and statistical portrayals provided by GIS facilitate inductive thinking and creative interpretations. In this role, the ability of GIS to allow the user to pursue alternative formulations, both completely new ones and marginal variations in existing ones, is critical. By allowing such formulations GIS facilitates the identification of patterns and general premises so important to inductive thinking. It is the novel formulation that has the greatest likelihood of sparking insight.

A basic tenet of information theory is that the occurrence of the expected or highly probable simply produces redundancy, not information. Unfortunately, expected patterns or messages, usually associated with a particular paradigm or theory, are the ones most easily separated from clutter or noise and, thus, the ones most likely to be perceived. Along these lines, Neisser (1976) posits that in an effort to conserve limited cognitive resources one's paradigm determines which stimuli are even recognized rather than, as commonly believed, which stimuli are received, processed, and then rejected. The central role played by paradigms in determining which stimuli are recognized is related directly to research findings indicating that humans tend to seek only information supporting their accepted beliefs, a phenomenon called confirmation bias (Evans, 1989). Conflicting or falsifying information may not be ignored when presented but generally is not sought.

Gombrich (1969), in his classic study of pictorial representation, summarizes this process and the need for interpretive flexibility:

Every time we scan the distance we somehow compare our expectation, our projection, with the incoming message. If we are too keyed up, as is well known, the slightest stimulus will produce an illusion. Here as always it remains our task to keep our guesses flexible, to revise them if reality appears to contradict, and to try again for a hypothesis that might fit the data. But it is always we who send out these tentacles into the world around us, who grope and probe, ready to withdraw our feelers for a new test.

By providing formulations, some of which may be surprising and contrary to the current paradigm, GIS offers an opportunity to recognize new information.

Adding structure to geographic description

Description is not limited to surveying or ad hoc methodologies invented and reinvented by the user every time a need arises. Organizing schemas exist for systematically approaching the task of geographic description. Consider Berry's (1964) suggestion that classification in geography be conceptualized as a three-dimensional matrix (see Figure 3). He proposed that phenomena be categorized in terms of type of activity, location, and time (as quoted in Fielding, 1974). This threefold division provides critical differentiating criteria exhibited by all spatial phenomena and generally of interest to real estate geographers.

By appropriately labeling the axes and slicing Berry's matrix with lines and planes, one can define many of the supply and demand studies for varying kinds of space of interest to real estate geographers. Supply studies of office space in general and particular types of office space at specific locations over specific time periods are examples of slicing Berry's matrix. Likewise, studies tracing the demand for office space over time can be portrayed using the matrix. Other spatial phenomena of interest to real estate geographers, such as home ownership and property tax assessment may be portrayed similarly. Thrall (1993a) represented homelessness as an activity within the context of Berry's matrix by identifying homeless and nonhomeless people, homelessness as a long- or short-term situation, and the locations of homeless people.
In another study, an entirely different phenomenon, property tax assessment, is analyzed using the same matrix foundation (Thrall, 1993b; Thrall, Elshaw-Thrall, Ruiz, and Sidman, 1993). In this analysis, time is held constant by selecting from all observations only those single-family dwellings that sold during a selected time period. Real estate geographers often are interested in the spatial concentration or dispersion of phenomena and the implications and ramifications of such geography. Thus, for descriptive purposes, Berry's matrix, either in total or sliced along one or more dimensions, is a viable metaphor for much of the descriptive activity engaged in by real estate geographers.

Stage two: Explanation

Uniqueness of location and the possibility of spatial explanations

Transitioning between description and explanation is fraught with potential difficulties in applied geography. The real estate geographer quickly becomes involved in at least one nest of philosophy of geography issues of immense importance. The core issue is whether explanation is possible in geography and the corollary issue is whether description is or should be the main and, perhaps, only objective of geography. The possibility of explanation in geography is related to a concept that is frequently considered an unquestioned real estate principle—that each parcel of real estate is locationally unique (Wurtzebach and Miles, 1994). Dasso, Shilling, and Ring (1995) label this attribute heterogeneity, reflecting the uniqueness of each parcel. Taken to its logical extreme, this uniqueness principle prohibits generalizations from any particular parcel or place to other parcels or places.

According to this viewpoint, we cannot make generalizations that allow us to apply what we learn from one location to understand the geography of another location (Hartshorne, 1939; Martin, 1994; however, see Lukermann, 1989 as quoted in Martin, 1994). Without generalizations that lead to theories it is impossible to develop explanations. If moving from description to explanation is not possible in geography, or in real estate in...
matters related to applied geography, then geography and GIS are of limited usefulness to	hose seeking to explain or predict. In such a world, GIS is a powerful descriptive tool but little else.

This so-called *idiographic* school of thought dictates that if each place is unique then there can be no generalizations, no geographic theory, no anticipation of geographic patterns—regardless of how compelling the evidence may be. Without generalization, there can be *no theory*. Without theory, *explanation is highly limited, if not impossible.*

However, if we believe that there are commonalities of like-kind geographic processes between locations, then each place, parcel, or location is not unique, and the door is open for geographic generalizations and geographic theory.

**GIS and real estate as integrative areas**

GIS, as the best available vehicle for integrating the various geographic data operations that are required for real estate geographic analysis, is the best vehicle for progressing from data sets of seemingly disparate data to inductive generalizations that may lead to theoretical insights. This geographic approach applies to a wide range of users who are defined by their interest in spatial aspects of problems, not by the subject matter. For example, while one GIS user may be interested in urban land markets and another in the natural environment, both are geographers because of a shared approach to analysis regardless of divergent themes reflecting particular areas of interest. Geography and real estate are not distinguished from other disciplines because of their development of ideas concerning specific themes. What differentiates geography and real estate from thematic disciplines such as physics, economics, and psychology is that geography and real estate—like history and geology—are integrative disciplines (Casetti, 1993; Grissom and Liu, 1994; Clapp, Goldberg, and Myers, 1994). This distinction between integrative and thematic approaches is important for the process of developing generalizations, theories, and explanations.

Thematic disciplines focus on comparatively narrow classes of phenomena, while the integrative disciplines address broad classes of phenomena, often overlapping with phenomena of interest to the thematic disciplines. Because of their narrow focus and concentrated research programs, thematic disciplines generally develop analytical knowledge earlier and to a greater extent than integrative disciplines such as geography and real estate. The rapid progress made by focused disciplines using well-accepted paradigms is consistent with Kuhn’s (1969) conception of normal science. Diaz (1993) further develops this concept by proposing a continuum of knowledge seeking with disciplines having a central focus and explosive knowledge growth at one end and those lacking a central focus and exhibiting creative anarchy and slow knowledge growth at the other. Real estate and geography tend to be toward the creative anarchy and slow knowledge growth end of the continuum. Grissom and Liu (1994) also note that the disciplinary diversity of real estate has prevented the development of an “orthodox theoretical framework for problem solving activity that is unique to the discipline.” Indeed, one may question whether real estate is a discipline at all, but rather may be described better as an area or field of study.

Within the scientific community, being at the creative anarchy end of the continuum has relegated geography and real estate to lower status as disciplines. Casetti (1993) writes that

the status of disciplines such as economics and psychology results partly from their ability to isolate several related clusters of relationships earlier on, and in the process to acquire de facto “property rights” over them. Also, in these disciplines the devel-
opment of theories, models, and validation techniques began earlier, went further, and culminated to a greater extent in well-recognized bodies of "analytic" scientific knowledge.

The integrative technology of GIS has altered the balance in the competition between thematic and the spatially oriented integrative disciplines. Geographic information technology has reduced the competitive advantage previously enjoyed by narrowly focused thematic disciplines by providing the ability to efficiently develop and test inductive insights critical to explanation.

Does geography theory exist?

The role GIS plays in the explanation of phenomena of interest to applied real estate geographers is closely related to the development of geographic theory in the form of Tobler's first law of geography (1970): "everything is related to everything else, but near things are more related than distant things." By implication, if you change your location by a small increment, the resulting change in the geographic environment is expected to be so small that one can anticipate what the geographic environment will offer there. Indeed, a question that often vexes those performing real estate market studies, valuation analyses, and many other real estate analyses is what constitutes a just noticeable geographic difference that would necessitate significant adjustments in a given parcel or site. Tobler's law is routinely applied in real estate in defining and working with the nebulous and fluid concepts of neighborhood, region, market areas for retail centers, and "comparables" in real estate valuation. If one believes in Tobler's first law of geography, then one believes in a geographic theory, which opens the door to accepting the existence of more geographic theories.

The best argument to the earlier challenge that "geography can have no theory," which parallels the same proposition for real estate, is the creation and presentation of geographic theory itself—namely, the "proof is in the pudding" argument. There are many examples of geographic regularities and geographic theory. For illustration, the human side of the geography discipline offers explanations for

- The spatial distribution of settlements referred to as central place theory (Christaller, 1966; King, 1984),
- The spatial distribution of land values and land-use patterns (von Thunen, 1842; Hoyt, 1933, 1939; Alonso, 1964; Thrall, 1987, 1991),
- Human migration (Clark, 1984),
- The manner in which people perceive and learn about the spatial environment (Golledge, 1978; Gould and White, 1986).

These are but a few geographic generalizations.

Many geographic generalizations are static. Static spatial analysis attempts to explain the state of affairs of a particular spatial phenomenon independent of time and without regard to how the state of affairs came about. One example of a static spatial theory from the above list is how urban land values vary from one location to another. Urban land values generally decline with increased distance from urban commercial activity centers. The explanation for this general trend is that people are willing to pay more for the benefits of a shorter commute and to pay less for the disadvantages associated with longer commutes.
This generalization can be used to explain the trend of land values in Vail, Colorado, Gainesville, Florida, or any other place. The precise shape of the spatial trend of land values depends on the aggregate behavior of those individuals who make up the market, their ability to pay to avoid the disadvantage of commuting, and the strength of their preference for avoiding the commute. Households, including temporary ones, in Vail are on average more wealthy than households in Gainesville, and Vail residents generally place a greater premium on being near the urban core than do residents of Gainesville. Therefore, the rise in land values with proximity to Vail’s urban core is expected to be greater than the rise in land values with proximity to Gainesville’s urban core (Thrall, 1987). Of course, housing must compete with other land uses for desired locational attributes, but the concept remains intact.

Geography theory, heuristics, and algorithms

The evolution of geographic theory has followed the same developmental evolution as theory in its related disciplines. First, in the description phase, the collection and inventory of “factual information” is coupled with loose literary and/or philosophically based generalizations and explanations (Casetti, 1993). In other words, a relatively coherent story is developed about the findings. The above narrative of land values in Vail versus land values in Gainesville, in which the story involves tradeoffs between dollar and time costs, falls within this tradition. In developing this narrative and, indeed, in identifying the questions that merit consideration, one’s paradigm or world view plays a critical role.

In the next phase of theory development, a model incorporating a more precise expression of concepts is formulated. Initial development, in which concepts are sharpened, assumptions identified, relationships explored, and potentially interesting insights identified may occur in a verbal, or literary, mode. However, this literary expression often quickly gives way to a mathematical expression of the model in order to make relationships explicit, facilitate manipulation of variables, systematically draw conclusions and possible extensions, and identify areas for empirical testing. In short, the mathematical representation may provide a more economical, explicit, and precise expression of the model.

In the explanation mode, whether the model is literary or mathematical, the emphasis is on identifying why the object or system under examination behaves as it does. Of particular interest to real estate geographers is the ability to identify how changes in one or more variables affect a selected variable of interest. These explanations may be heuristic or algorithmic in nature. The two approaches differ in the level of certainty of generating a solution.

Algorithms are step-by-step recipes that guarantee an answer to a problem if all the necessary data are available. In using algorithms, the question is not whether an answer will be generated but whether it is the appropriate answer for the problem at hand. For the well-defined problems discussed earlier as occupying the upper right portion of Figure 1, matching algorithms and problems is a relatively straightforward and productive effort. However, there are inherent limitations to using algorithms when novel or changing problems are involved.

Algorithms are designed to be used in a well-defined set of circumstances. As such, algorithms are prescriptive, following an “if these problem elements are present, then this algorithm will produce a solution” format. For example, if a problem requires the use of long division for solution, then the familiar algorithm for performing long division provides a step-by-step solution technique. Its proper usage guarantees a correct solution to the problem. If the problem elements and, hence, the problem, change, then a given
algorithm may no longer be appropriate. Likewise, if a poorly defined fact situation is distilled into a poor problem representation in order to fit an algorithm, the resulting answer solves only the represented problem, not the real problem. Algorithms work well in appropriate situations, but there is a danger in applying an overly prescriptive approach to solving poorly defined or ambiguous problems (Reason, 1990).

Thus, if a problem is well defined, the use of an algorithm to generate a guaranteed solution is the obvious and appropriate action. However, many interesting real estate problems are not well defined, and in such cases the use of an algorithm will produce a precise but incorrect solution. It is in the domain of poorly defined problems that heuristics may provide a mechanism for progressing toward a solution. Heuristics do not guarantee solutions but offer only an approach that may be helpful. Starfield, Smith, and Bleloch (1990) define a heuristic as follows:

A heuristic is a plausible or reasonable approach that has often (but not necessarily always) proved to be useful; it is not guaranteed to be useful or to lead to a solution. This is just a more formal way of saying that it is a rule of thumb.

Heuristics, or rules of thumb, abound in real estate. Astute real estate problem solvers know that such heuristics sometimes lead to solutions and sometimes lead to dead ends. A heuristic must be used with care and attention to the problem context in order to maximize the likelihood that it may help solve the problem.

In actuality, the Vail-versus-Gainesville narrative above summarizes the implications of a geometry-based mathematical construct—a mathematically precise, general heuristic methodology that can be applied to evaluate the land use and land values of almost any urban situation (Thrall, 1987). What does the world of GIS have to do with the world of mathematical constructs designed to tell a story of relationships and causation? Actually, GIS and the worlds of theoretical and algorithmic constructs have a circular relationship in which one affects the other in an ongoing feedback process.

**Inductive and deductive reasoning**

Theory links GIS to the larger body of knowledge. GIS does not stand in isolation from a larger body of knowledge; rather, its utility hinges on its linkages to a larger body of knowledge. At the same time, in a circular manner, GIS is now shaping the questions we expect our general theory to answer. In this regard, GIS provides a vehicle for observing the regularities that lead to alternative ways of viewing phenomena and the inductive reasoning that leads to fresh insights. And, because GIS is so efficient and effective in its spatial data visualization, it gives rise to an awareness of phenomena in an unprecedented manner.

GIS can inform us about the landscape of the spatial database at hand. The modern geographer explores the virtual landscape residing in the computer, armed with the belief that within the particular spatial database may lie the outcomes of general spatial processes. This type of research has been labeled “exploratory” by Clapp, Goldberg, and Myers (1994) and is considered to be a prescientific activity that identifies new relationships and uses them to create new theories and, ultimately, new paradigms. Compared to the ability of GIS to produce “aha!” insights, the deductive mathematical heuristic approach looks rather staid. However, inductive and deductive reasoning should be viewed as two elements of reasoning working in concert, not in competition.
In this regard, deduction often has been considered more rigorous than induction in scientific problem solving. One reason is that induction suffers from Hume's fallacy of induction—the notion that inductive insights can never be proven but can be disproven by a single contradictory observation. For example, induction causes us to think that the sun will rise tomorrow morning, but this inference cannot be proven. However, induction can be used profitably and in ways that maximize the likelihood that its insights are warranted.

At least three variations of standard induction intended to make its use more attractive merit attention. Clapp, Goldberg, and Myers (1994) cite the work of Platt (1964) in developing what is called "strong inference." Strong inference combines elements of deductive logic into inductive studies. Baron (1994) proposes the search-inference framework for inductive reasoning. This framework breaks the inductive process into three kinds of objects: possibilities, goals, and evidence, and then proceeds to develop an inductive framework around them. Another model worthy of examination is the Bayesian approach posited by Howson and Urbach (1989). All three of these approaches to inductive thinking may have merit in real estate geography. They may help inductive research overcome some of its most stinging criticism—that it is ad hoc and often part of the research equivalent of fishing expeditions, or as one wag has put it, "The data are tortured until they confess."

In considering the role of deductive and inductive research, any myths of scientific progress and the process by which science progresses must be separated from reality. Kuhn (1969) portrayed science as a sociological process, not always proceeding neatly from one set of theories to a new and improved set of theoretical constructs based on purely rational considerations and deductive reasoning. Likewise, Brush (1974) and Bauer (1992) highlight the differences between the popular, romanticized perception of science and how it is actually practiced. Science needs researchers pursuing alternative paradigm development, an activity that often embodies inductive thinking in order to identify new ways of looking at old or accepted patterns. It also needs researchers working in a deductive mode to develop mathematically precise theory, to build testable hypotheses, and to perform appropriate tests of those hypotheses. The point is that neither deductive nor inductive reasoning holds the trump card. Both are necessary elements in the development, evaluation, evolution, and, in the Kuhnian sense, revolution of science and problem solving.

GIS makes basic spatial data description so powerful and productive that users who specialize in creating heuristic explanations simply cannot keep pace. The technology of description has outpaced our collective ability to explain. Consequently, those who are creating the vast array of well-documented, descriptive analyses that require explanation are now, for lack of anything better, falling back on the earlier more imprecise forms of explanation: loose literary and/or philosophically based generalizations and explanations. Such inductive processes may provide the seed for the development of preparadigmatic thought that may lead to a new round of deductive thinking and progress in theory development. However, the burden shifts to the mathematically precise theorist to keep up, to supply the GIS community with explanations of their newly visualized landscapes. It is likely that the near future will offer even greater disparity between the ability to describe, pose questions, and develop hypotheses and the ability to explain what has been documented.

Such a situation is not new. In geography it has been noted (Thrall, 1987) that

Regrettably, one of the weaker aspects of ... [spatial analysis] has been linking the formal theory with formal empirical-statistical analysis. The audience for ... theory has been largely limited to other theorists. Empiricists are all too often unfamiliar with the theory; their research agenda has been based largely upon their personal experiences
without the benefit of the theory. The burden for this weakness does not fall only upon
the empiricist; too often theorists have made little attempt to communicate their find-
ings to empiricists. More important, there have been too few urban analysts who have
made the effort to contribute to both theoretical and empirical analysis.

This state of affairs has not changed, with the exception that in 1987, the date of the above
quotation, mathematical theory had the comparative advantage over most empirical work,
especially data description. Recent developments in GIS technology have eliminated or
reversed the advantage; data description and inductive reasoning are much more useful
and more accessible today than in the past and has much to offer those formulating
explanations.

Stage three: Prediction

We nudge toward prediction when we ask “what if” comparative questions of our static
explanatory analysis. Prediction in this sense does not require a temporal dimension. That
is, the application of the model may seek to explore what changes may accompany
changes in selected variables without regard to time. Indeed, in many instances systems
capable of predicting or retrodicting atemporally from event to event are sought. However,
many interesting real estate problems involve the more common temporally based concept
of prediction or retrodiction. Whether temporal or atemporal, prediction is concerned with
assessing the impact of change on a variable or variables of interest. In a temporal mode,
corrn shifts to changes over a specified time period or assessing the amount of time
necessary for specified changes to eventuate. Deterministic and stochastic models are
considered.

Deterministic models

Generally, interest is focused on the problem states before and after a change. an approach
called comparative statics. This approach is contrasted with dynamics, an approach that
considers the detail of the move from the starting situation to the new situation, or vice
versa. One reason for the general use of comparative statics is that it is generally easier to
assess before and after positions that it is to assess before and after positions and explain
all the steps in between.

To illustrate comparative statics, we can pose the question, “How would land values be
expected to change if a new urban activity center were to arise in addition to a single
urban central core as in the Gainesville-versus-Vail narrative?” (Thrall, 1987). Comparative
static analysis describes the state of affairs in each scenario: land values before the
new activity center and land values after the introduction of another commercial activity
center. If the new activity center has not been built, then the comparative static analysis
allows us to anticipate the trajectory of land values as a result of the introduction of the
new commercial node.

The prediction of the trajectory and final position may be derived from a heuristic or
algorithmic approach. Heuristics may be utilized in order to produce an estimate of the
general direction of change or a rough estimate of the magnitude of the change, or both.
Algorithms may be used to produce precise estimates of the new situation. Which is used
depends on a number of factors.
Much mathematics-based geographic theory can be classified as being of the heuristic type—that is, the theory tells a general story and can be related to the specific circumstance only by analogy. The value of heuristic theories is in their ability to provide anticipation of the trajectory of change but not the precise expected numeric magnitude of the change. The familiar economic heuristic of supply and demand provides an example of the use of heuristics. For example, suppose the supply of oranges declines because of a hard freeze. Assuming that demand does not change, the supply curve will shift, and the price of oranges will rise. The heuristic prediction is a trajectory of the general form "prices rise." The heuristic explanation for the rise in the price of orange juice is that the hard freeze reduced the supply of orange juice. This heuristic can be applied only by analogy to any specific real-life situation, and then it will not provide a precise estimate without additional detailed research.

In many problem-solving situations it is reasonable to ask, "Why bother with a heuristic trajectory prediction when the more precise algorithmic numeric prediction can be much more valuable to our judgment?" Knowing that land values three miles from the new urban activity center will increase by 15 percent following the introduction of the activity center is more valuable than knowing only that land values will increase. There are several reasons why a heuristic trajectory may be acceptable to a problem solver.

One answer is that the heuristic prediction can be referred to as a "first prediction estimate." It is a cheap forecast: no computer time is required, generally no expensive data are necessary, no software has to be purchased. The heuristic prediction depends entirely on investment in human capital: education, training, experience, time, and imagination focused on creating an abstract heuristic methodology as a mental shorthand. But the danger with mental shorthand is that systematic biases may be introduced. The replacement of critical thinking with heuristics, often a necessary data-reduction device in a complex, uncertain, and dynamic world, leads inevitably to bias and irrationality in cognitive processes (Tversky and Kahneman, 1981; Piatelli-Palmarini, 1994; Evans, 1989; Dawes, 1988; Thaler, 1991). Care must be exercised in order to prevent such irrationalities from significantly affecting the problem-solving process when heuristics are used.

Another reason heuristic prediction may be attractive is because it can be the "first out the door" and, moreover, is often the only forecast estimate available. A trajectory is better than no information at all. The heuristic estimate also plays a more important role. It provides anticipation and explanation for the outcome, places boundaries on the problem at hand, helps establish the procedure for the desired numeric prediction, provides the first line of defense for evaluating the credibility of the numeric prediction, and improves our general intuition—our reasoning—so that we can better anticipate the what, why, and where in our environment.

A potential problem with using heuristics in order to produce an expeditious first prediction is that heuristics may determine how a problem is framed and represented. Choosing a particular heuristic casts the problem in a particular way and converts the fact situation into a particular representation or frame. Research indicates that framing is critical to problem solution because how a problem is framed affects the development of solution alternatives, the tools considered appropriate for the problem, and the selection of the preferred solution option. Thus, the selection and use of heuristics has a profound impact on problem solving.

Algorithms, as precise expressions of geographic concepts relying on mathematical constructs, are not without critics (Thrall, 1985):

Some extremes in mathematical content [have] been taken by some in our discipline, where the spirit of rigor in mathematics has led much pure theoretical research to be sterile in substantive content; ... it is not sufficient to evaluate research by using the
criteria that (a) no mathematical errors are made, (b) only the most minor of assumptions are required, and (c) great attention is given to logical consistency, elegance, and rigor. Such criteria on their own may allow one to theorize complacently about imaginary worlds … implications about which are neither intended for nor capable of empirical verification … [such work is] substantively vacuous.

British geographer Openshaw (1989) take these comments further (as quoted in Johnston, 1993):

The deductive route to theory formulation has not been particularly successful. Far too many so-called “theories” have never been tested and many more are untestable! … They are “massively theoretical” rather than applicable, and of dubious relevance.

In economics, this same sentiment has been expressed by Hirshleifer (1976):

But on the other hand, economics is not a branch of mathematics, a body of theorems deducible from given postulates. Unfortunately, one sometimes encounters intellectually muscle-bound theorists, overtrained virtuosos who may be knowledgeable about frobenius matrices and conditions of multi-dimensional dynamic stability, but are at a loss to explain why vegetables are cheaper after the harvest than before.

Once again, the contrast between the inductive world aided by GIS and the purely deductive world is made clear. As Laudan (1982) suggests, the validity of a paradigm is related to its ability to solve problems not solved by competing paradigms. GIS and its support of inductive reasoning has much to contribute to problem solving.

Stochastic models

A second type of predictive geographic model is the stochastic model, in which interrelationships are expressed and measured using probability-based measures. These geographic models are generally less valued for their ability to explain than for their ability to produce reasonable and acceptable forecasts. Examples of this class of models—again from the human or social science side of the discipline—include

- Geographic market evaluation known as gravity and spatial interaction models (Haynes and Fortheringham, 1984) and
- Spatial diffusion (Monte Carlo) models that forecast the spread of phenomena from limited origins to other locations through time (Hagerstrand, 1953; Brown, 1981; Morrill, Gaile, and Thrall, 1988; Thrall, Sidman, Elshaw-Thrall, and Fik, 1993).

These models have generally produced good predictive results, but to some this success is the exception rather than the rule when it comes to solving real-world problems.

For example, notwithstanding the successful forecasting accomplished with geography’s gravity and diffusion models, Casetti (1993) writes that

The social sciences [overall] are collectively under attack … because of their inadequate performance. These [attacks] focus upon their creating models and theories that do not come to grips with reality, upon their inability to produce reliable predictions and forecasts.
This reality disconnect is often associated with a corresponding disconnect between the developers and users of models. Openshaw (1989, as quoted in Johnston, 1993) writes, “No one has seemingly ever asked who are the potential users for geographical models. Previously it never mattered; today it does!” The reason it matters is because applied geographic analysis, including that used in real estate, now has relevance.

Openshaw (1989) also confronts the gnawing issue of rigor or relevance by positing that the large new market for good geographic predictive models leads to analyses that may lack “any strong theoretical justification” but are immensely successful. The cost of quickly achieving good predictive models in response to market demand “might well be a reduction in the emphasis on explanation (rigor) and the tacit acceptance of a different and inferior form of understanding … [to] give models in human geography a greater degree of relevance and marketability.” The reduced emphasis on explanation may be translated as a reduction in rigor. While these models may, indeed, be different, the extent to which they may be inferior is a function of perspective.

From the deductive theory point of view, the models may lack an appropriate theoretical foundation—a lack of rigor. From the practical problem solving point of view, such models may not be inferior at all; they may be perceived as providing reliable solutions to very difficult practical problems. Under the appropriate conditions, a certain level of deficiencies in theoretical rigor is traded for a higher level of problem-solving relevance. Furthermore, such models need not be developed on an ad hoc basis; as discussed earlier, techniques exist for using inductive reasoning in a more structured manner. There is a significant difference between ad hoc inductive model development and the exploratory research identified by Clapp, Goldberg, and Myers (1994). Real estate geographers must be aware of this difference and exercise care in applying inductive reasoning in model development.

Stage four: Judgment

The integration of judgment into GIS analysis has only recently begun to receive the attention of scholars producing university-oriented GIS literature; therefore, the technology of this component of GIS is not well developed. It has been referred to as computer-assisted decision strategy (Thrall and Elshaw-Thrall, 1990), implying that GIS is one part of a larger information technology that may be drawn on to improve our judgment. Such efforts also have been labeled as spatial decision support systems (Ralston, Tharakan, and Liu, 1994). Regardless of the terminology, using GIS to improve judgment in real estate is a crucial stage in reasoning with GIS because it links GIS to the segment of the market economy that attracts our attention. This stage ultimately gives GIS its value based on the willingness of GIS consumers to pay for improved problem solving, ultimately resulting in better decisions.

It is likely that providing support for a human decision maker rather than replacing that decision maker is the role GIS will play for some time. Replacement approaches that seek to improve human problem solving and decision making by replacing the human have had success in situations involving large volumes of domain specific knowledge and strong associationist demands, such as medical diagnosis. These systems use brute force and unwavering computer power in place of more efficient human cognitive heuristics. Many interesting problem situations in real estate are not well defined or static enough to make extensive use of extant replacement approaches.

An alternative approach is an interactive decision support system with less complete knowledge to assist humans in structuring problems, developing options, and making decisions (Evans, 1989). GIS may play an important role as a problem structuring aid for
the ill-defined problems common to real estate (Wisudha, 1985). Problem-structuring aids assist the problem solver to develop a problem representation by making relationships clearer and helping to integrate the component parts. The graphical approach GIS affords provides unique ways to display information in order to reduce the problem of automatic thinking. It is the ability to aid in the early stages of problem solving in which the problem is defined and options shaped, as well as the later stages where decision making occurs, that makes GIS a radical departure from other tools.

Groups often play an important role in the decision-making process for a variety of reasons. First, rarely is one individual capable of evaluating the importance of the wide array of all considerations that must be part of a final judgment. Second, organizational structures frequently require a team effort for problem solving. Groups are afforded the opportunity by GIS technology to have input into the judgment process and communicate that input graphically. A Delphi-like procedure has been used to build consensus among the various constituencies of the decision-making process (Thrall and McCartney, 1991; see also McCartney and Thrall, 1991). Once again, the statistical and graphical capabilities of GIS afford the maximum opportunity for concisely communicating information, assumptions, and conclusions, a fundamental step in group problem solving.

As GIS technology incorporates artificial intelligence, neural networks, fuzzy logic, and other advances in cognitive psychology and cognitive science research on problem solving and decision making, the judgment component will be enhanced. However, as discussed earlier, it is not likely that GIS or other technology will replace human problem solvers in real estate in the near future. In the meantime, GIS offers a viable tool to help overcome the difficulties inherent in real estate problem structure and the limitations on human cognition, and the problems these limitations produce.

Stage five: Implementation

Implementation has two connotations: the implementation and management of problem solutions and the implementation and management of the GIS itself. With respect to solution implementation, GIS provides a mechanism for monitoring the accomplishment of specified goals and changing conditions over time. Using GIS information, strategies can be adjusted to changes in critical variables. GIS has the same usefulness in implementing and managing a solution as it has in solving the problem and making the decision.

Implementing a GIS process takes two forms: (1) the creation and management of the source geographic data as input into the GIS process and (2) the management of geography-based information that is output from the other four stages of GIS reasoning. Managing a GIS has important implications. By virtue of being a system, GIS has parts that can interact in unpredictable ways, perhaps producing unexpected results. For this reason, GIS requires a combination of user and manager. A manager directs and controls processes while a user utilizes judgment, experience, and skill to shape the process (Tenner, 1996). GIS requires both skills and approaches.

The problems inherent in earlier efforts to implement local government GIS, particularly countywide geographic databases have been documented (Thrall, Bates, and Ruiz, 1994; Thrall and Ruiz, 1994). Those local governments that adopted GIS early had problems because the early technology was often being developed as it was implemented. Later-adopting local governments benefited from an industry having learned how to implement a countywide GIS and having already developed the technology required for that implementation.
Today, the market for new adopters has shifted to the private marketplace and the business firm. Businesses want off-the-shelf, turn-key, ready-to-use technology. GIS vendors are responding to this demand by offering more user-friendly software and by offering easy-to-access, GIS-ready data. Access to affordable data and quality software is a giant leap forward; however, many businesses adopting GIS today will be disappointed, as were early adopting local governments. The technology is not in place to bridge the gap between making a GIS map on the one hand and making a good business decision on the other. This situation is analogous to other technology, such as spreadsheets. For example, purchasing a popular spreadsheet software program and installing it on a computer does not make one an expert in finance; the spreadsheet is a vehicle for making financial analysis easier for those who already know finance. Likewise, today’s GIS software is designed to make geographic analysis easier for those already familiar with spatial reasoning.

As the business community adopts GIS, it will go through a process of self-discovery, and many firms will find that its management and staff are not trained in basic geographic concepts and not ready to use geography to improve its decisions. The market will respond in two ways. First, the demand for trained real estate geographers (spatial analysts) will increase. Innovative business schools will take steps to include geographic reasoning and GIS technology in their curricula to prepare their students to take advantage of this market. Second, GIS software vendors will offer market-niche software targeting specific needs for specific classes of businesses. These niche markets represent a significant growth segment for the GIS industry in the near future (Thrall, 1996).

GIS will benefit from the overall effort to remove the arcane human/computer interface that has hampered computer usage. The interface burden will be shifted from the human to the machine (Negroponte, 1995):

The challenge for the next decade is not just to give people bigger screens, better sound quality, and easier-to-use graphical input devices. It is to make computers that know you, learn about your needs, and understand verbal and nonverbal languages.

Improving the interactive nature of GIS will occur as multimedia gives way to hypermedia in which users can easily move from one medium to another and access a body of information and ideas at any level of analysis and detail. Coupled with this new interactivity will be the demise of CD-based systems and their replacement with systems capable of providing constantly updated information automatically filtered for the demands of the user (Negroponte, 1995). The World Wide Web is a technology that is beginning to deliver on this promise. The ability of GIS to enhance the creative, intuitive processes of real estate problem solvers will be a remarkable aid in reducing the impact of cognitive limitations and improving problem solving.

GIS, academia, and markets: Selected issues

Bells, whistles, rigor, and relevance

The mixing of academia and the market bothers some geography academicians. For example, geographers Driver and Philo (1985) write: "computer-aided analysis of complex data sets … technical wizardry cannot itself supply us with explanations." This statement is no doubt true. They continue:
The widespread concern about government cutbacks in education budgets or current directions in research funding ... reinforce the increasingly technocratic nature of geographic research ... Technocratic geography effectively marginalizes all other modes of interpretation and explanation. It encourages geographers to seek out the very latest in digital mapping, data processing, or remote sensing facilities.

From Driver and Philo’s point of view, this urge to seek out technology is most undesirable. For real estate geographers steeped in the finance paradigm, the technocratic approach is not nearly so distasteful.

In conclusion Driver and Philo (1985) write, “Even if such techniques enhance the ‘image’ of our subject, as Thrall contends, they do little to make it more ‘relevant’ in either academic or social terms.” We agree: the soul of GIS is not in the machinery; it is in the creativity and cognitive skills of the user. Put differently, it is not the GIS technology sitting on the shelf or even installed on a computer that makes geography relevant and creates value. Rather, it is what practitioners ultimately do with the technology that creates value. If the creative application of GIS improves problem solving, then it will have a positive value. This is true whether the problems to be solved are in geography or real estate.

Ron Johnston, a philosopher of geography, subsequently categorized the contention that GIS may contribute to practical problem solving and thus have value as being among the “radical approaches” to geography (Johnston, 1991). The “radical” label underscores a problem with geography academia today, as well as a decade ago. It was considered radical by the academic geography discipline to emphasize that in addition to being rigorous, geography should be relevant—that it should be applied. It was considered radical to note (and to take advantage of the fact) that relevant computer-based geography can contribute to the generation of profits. Perhaps what is often characterized as a dichotomy between relevance and rigor is actually a blending, one with subtle shadings in which the two attributes are combined. If one must be considered a radical for suggesting that geography or real estate should be relevant to problem solving, then being considered a radical carries little or no stigma. There is room for both rigor and relevance.

The terms relevance and marketability are critical to understanding market-driven GIS today, particularly GIS-based spatial forecasts that transform geographic data using mathematical models. In the information age, mathematical transformation of data adds value. Openshaw (1989; as quoted in Johnston, 1993) writes that

Adding energy in the form of organization and analysis imparts value to bits of information that previously had high levels of entropy and capable of being interpreted in many different ways. Negroponte (1995) provides an extensive discussion of the possibilities of adding value to bits through processing and manipulation and the possibilities of narrow-casting information rather than using magnetic or optical media. He also discusses the development of systems that “learn” the needs of the user and automatically perform screening and computational functions. As GIS evolves, these capabilities will significantly increase its rigor and relevance and, hence, its value to real estate analysis through better prediction.
Side effects and unintended consequences

Improving problem solving is critical in order for GIS to avoid the problems associated with other real estate problem-solving and decision-making technologies. In an excellent summary of real estate decision-making, Roulac (1994) provides a hard-hitting critique of how other technologies have failed to improve real estate decisions:

Despite quantum advances in the technology available to support real estate decisions, the progress in adapting such technology has been less than impressive. Simplicity still dominates sophistication, even though simplistic approaches may lead to suboptimal decisions. Too often, those making real estate decisions employed a deal making, rather than a strategic orientation. Lacking a context, decisions at the margin will often be marginal.

Tenner (1996) contends the same process applies to business in general:

Given more data and more powerful analytic tools, is it reasonable to assume that the quality decision will be correspondingly higher? This may seem plausible, and possible. It may even be true. Yet only a handful of studies exist. After all, why try to prove what everybody knows intuitively and what is built into the curriculum of business schools? The problem is that there is growing evidence that software doesn’t necessarily improve decision-making.

Technologies are not simply neutral; some may have detrimental effects associated with them. As an example, Roulac (1994) specifically addresses the impact of the use of spreadsheets in real estate financial analysis:

Financial analyses presented in spreadsheet formats on computer paper assumed an unwarranted legitimacy unsupported by the validity of the assumptions, sophistication of the analytic model itself, and the probable confidence of the analyst preparing such analyses, an insidious, but not necessarily useful, phenomenon known as the “black box effect.” But the very availability of a “new toy” attracted considerable interest and attention from academics and researchers who devoted their energies to writing cash-flow models, at the expense of more significant and important strategic and conceptual issues.

What began as a straightforward technology to improve productivity and to allow the analyst to concentrate on the critical elements in performing financial calculations had unintended consequences in the form of side effects and revenge effects (Tenner, 1996). The side effects include unwarranted confidence in the results. The revenge effects, those mitigating against efficiency and improved concentration on and attention to critical factors, resulted from the distraction of the technology and the energy directed to nonessential aspects of financial analysis—the technological equivalent of taking one’s eye off the ball with a full count.

Unintended consequences for GIS technology are wide ranging and, like all technology, potentially troublesome. General discussions of unintended results are to be found in Tenner (1996) and Burke and Ornstein (1995). Pickles (1995) provides a detailed account of potential issues and social implications of GIS usage from various perspectives. Indeed, GIS usage will not be as smooth as hoped or without potential problems. However, in marketplaces in which profits are dependent on information arbitrage, it may be self-destructive not to use GIS. This is true in less efficient markets in which above-normal
profits are sought and in more efficient markets in which the goal is to develop a portfolio that produces the appropriate market rate of return for the risk assumed.

Certainly, many technologies have produced results other than those desired because of a lack of attention to the possible outcomes. However, some technologies have essentially worked as intended, and others that have not have resulted in upgrades that have functioned more nearly as intended. The process of designing, testing, and revising is an established one in science and technology. Failure, however defined, and its remediation are part of the development process of virtually any technology (Petroski, 1992). Technological determinism does not mean that any and all potential problems will be realized (Trefil, 1994) And, of course, not all problems can be neatly placed at the door of technology; the motivation and attention of those using the technology often are the critical factors in the application of the technology. As Reason (1990) points out, the range of possible human error in all manner of systems is vast.

The potential dangers inherent in the use of GIS are clear, although the prescriptions are more ambiguous. Real estate geographers must take care to use GIS when appropriate without becoming enamored with the technology to the point of distraction. Developing ever more arcane approaches quickly produces decreasing marginal returns. There is a beneficial and productive use of GIS technology, but the goal of solving real estate problems, theoretical and applied, must be kept firmly in mind.

Conclusions

This article has considered real estate problem solving and the role GIS may play in the problem-solving process. The article summarized real estate decisions as complex, dynamic, and uncertain and, therefore, resistant to solution. The major stages in the real estate problem-solving process were identified. Following these basics, the article presented a stage model of reasoning, composed of the elemental cognitive activities common to all stages of real estate problem solving. The stage model provides a framework for examining how GIS affects real estate problem solving. The stage model considers the cognitive elements of description, explanation, prediction, judgment, and implementation. Although they are presented in a sequential manner, one stage is not inherently more important or better than another. Furthermore, most applications involve a blending from one stage to another, along with a shifting back and forth between earlier and later stages.

Using the stage model of reasoning, it was shown that GIS has the potential to contribute to real estate problem solving. It has potential value because it improves real estate problem solving. In an industry in which profits rely on information arbitrage, the use of GIS may be a necessity. GIS is not without potential problems. An uneasy alliance between academia and markets continues to be a source of debate. Likewise, the side effects and unintended consequences associated with GIS merit exploration.

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