Examining the Role of GIS in Valuation

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Abstract

Developments in technology have made possible the new efficiency with which to handle spatial problems. This is increasingly being achieved through the implementation of Geographical Information Systems (GIS). Since many aspects of valuation require analyses of factors related to location, the potential benefits of GIS to this discipline cannot be ignored. This paper attempts to examine the role of GIS in property-related functions, with special reference to valuation and analysis of property values.

Keywords: Geographical Information System (GIS), spatial correlation, spatial data, true distance representation/ trend surface analysis.

Introduction

The developments in computing technology have been mainly responsible for changes in the way property valuation is approached. They enable valuation and other property-related analyses to be undertaken to a degree that would have been time-consuming manually. Advancements in technology have also led to a growing number of analytical tools to be exploited for valuation. Indeed, techniques such as econometric modelling, regression analysis and other advanced statistical methods have been employed to automate valuations. According to Wyatt (1995), artificial intelligence in the form of expert systems and neural networks, and more recently an object-oriented approach known as case-based reasoning, has also been explored.

Developments in technology have also made possible the new efficiency with which to handle spatial problems. This is increasingly being achieved through the implementation of Geographical Information Systems (GIS). Since many aspects of valuation require undertaking analyses of factors related to location, the potential benefits of GIS to this discipline cannot be ignored.

The aim of this paper is to examine the role of GIS in property-related functions, with special reference to the valuation and analysis of property values. In doing so, the paper reviews some of the studies undertaken that apply GIS to valuation, assesses the benefits to valuation of incorporating GIS, highlights implementation issues, and considers the possibilities for future work in this area.

The Essence of GIS

There is no universally accepted definition of a GIS. The reason for this lies partly in the fact that, as a tool, GIS finds application across a diversity of user backgrounds. Because of its substantial value as a tool in many spatial analysis situations, GIS has attracted both technical and application-oriented workers from a large number of disciplines. As the individual disciplines apply GIS within their own area of interest, each tends to discover, understand, interpret and perceive GIS in the context of its own. Different views thus emerge with regard to what constitutes a GIS.

As a result of this state of affairs, there is a broad range of meanings with which GIS is associated. To some, GIS means only the suite of software used to analyse geographically-referenced data. To others, the term includes the hardware utilised by the system. Again, others would include all processes from data acquisition to data presentation. The Department of Environment, UK, (1987) defines GIS as "...a system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced to the Earth". This is normally considered to include a spatially-referenced computer database and appropriate applications software.

There have been attempts to identify criteria to define GIS (Maguire and Raper, 1990) and to categorise systems (Bracken and Webster, 1989) but definitions have remained a matter of individual opinion. Despite the fact that existing definitions are fuzzy, the term GIS is now in such universal use that it will be difficult to replace it with an alternative term.

Whatever the definitions offered, and so as not to be carried away by the semantics, this paper will focus on the functionalities a GIS potentially offers. A definition that, in the broadest sense, encapsulates the processes and activities of GIS in dealing with spatial data would therefore be accepted. As such, the authors choose to understand a GIS as a method for the organisation and analysis of geo-spatial data. Within this definition lies the major functional components that a GIS is expected to have: a data input sub-system, a data storage and retrieval sub-system and a data reporting sub-system.

It should be noted that the above definition makes no mention of the technology. This is because as a concept, GIS has been in existence even before the current computing technology exists. In fact, as a methodology for organising and analysing geo-spatial data, GIS has existed even before the advent of computer technology, although in the more rudimentary storage form of paper and file cabinets. GIS does not owe its existence to the computer; the computer has only provided the technological platform on which GIS has prospered to a level of sophistication that we see today. This remark merely serves to remind us of the existence of the traditional form; the interest of the present discussion, however, will be on the modern computer-based version that we now know of.

Before we review the GIS for valuation related functions, a brief discussion of the nature of valuation and value will be presented first to give an understanding of the roles GIS could potentially take.

The Nature of Valuation and Value

There are many definitions of valuation. According to Millington (1988), valuation is "the art, or science, of estimating the value

for a specific purpose of a particular interest in property at a particular time, taking into account all the features of the property and also considering all the underlying economic factors of the market, including the range of alternative investments". In reality, valuation is a mixture of both the art and the science; in some instances the scientific content in it will be greater, whilst in other settings the process could be almost entirely an art. The scientific part of valuation derives from the analysis of data and the mathematical calculations of value; the art lies in the skill of knowing which information to use to assist one's valuation, and the process of making judgements and forming opinions.

Similarly, there are many definitions of value, "for land can have as many values as there are purposes for which a valuation is required" (Turner, 1977). Again, value can be a subjective notion in the sense that the appreciation of it can differ from one person to another. As an example, it is common for land to be worth more to the person who owns it than to someone interested in buying it. However, where an impersonal, objective measure is called for, the most common basis of value used is an open market value, which may be defined as the price the land would fetch if put up for sale in the open market by a willing seller and purchased by a willing buyer. It is in this impersonal, objective value that interest normally lies.

Property values are determined by a whole host of factors, which originate from both within and outside of a property, and which often interrelate between one and another. When considering the determinants of value therefore, most valuers will take account of or have regard to a number of important characteristics of property. Spatially, a property has a fixed location which means that it can only be used at that geographical location and therefore its value will depend upon the market's attitude towards owning a property at that specific location. Property also has a long life so that any sum paid has to be a fair reflection of the future benefits to be derived from the property. Purchasing property involves a substantial capital outlay; thus the availability of mortgage facilities and their costs are fundamental to the property market. Further, the total supply of particular types of property cannot be increased; duplicates are rarely of the same value as the originals.

The fact that a property is located in a particular neighbourhood - a spatial factor - also plays a part in determining property value such that the value of a superior property surrounded by inferior properties will tend towards the value level of the inferior properties, while an inferior property surrounded by superior properties tend towards the value tone of superior properties. This is also referred to as spatial correlation. This phenomenon takes place through the impact neighbourhood properties have on the value of subject property.

Role of GIS in Valuation

One benefit of GIS to valuation lies in its ability to provide useful representations of various spatial phenomena, often in the form of maps. Maps are an indispensable tool for understanding and interpreting spatial patterns and relationships. Maps can also be an important medium for communicating spatial messages. In fact, the messages a map conveys are often selective and partial models of the real world (Aalberts and Bible, 1992).

As a factor influencing property value, location is widely regarded as the most important. In practice, however, location is much talked about but under-analysed, and its incorporation into valuation methodology is often implicit. Appraisers often pay lip service to location analysis in arriving at value estimates. In the United States of America (U.S.A.) for example, appraisal standards require the three approaches to value to be preceded by material on location. Mostly, however, this material ends up being descriptive rather than analytical. Even when it is analytical, it is not usually linked with the valuation process by a proper line of reasoning. A GIS, by providing an efficient means of analysing locational or spatial data held by valuers, could allow explicit consideration of the spatial influences to be made.

All valuation techniques rely on the collection and analysis of data: general data such as social, economic, planning and environmental attributes, and specific data including local market conditions, details of transactions such as location, physical and functional form and legal characteristics. A GIS enables this by pulling together data from diverse resources into a single source.

Spatial analysis allows us to study real-world processes by developing and applying models. Such models illuminate underlying trends in spatial data, making new information available. A GIS enhances this process by providing tools which can be combined in meaningful sequences to develop new models. The models may reveal new or previously unidentified relationships within and between datasets, increasing our understanding of the real world.

All the above point to the reasons why a GIS holds potential for valuation. GIS is capable of providing the necessary analysis techniques for valuation. Since valuation involves a certain level of subjectivity in its decisions, an important role for GIS is seen to be in bringing down that level of subjectivity in valuation analysis. Objectivity in valuation has become increasingly emphasised as a result of the pressures, from both within and outside the valuation fraternity, for greater transparency and clarity in the way valuation is expressed. Thus, a potential contribution to be made by GIS will be towards making valuation more of a rational approach.

Potential for Improvement in the Valuation Process with GIS

Geographic information in the traditional valuation and real estate analysis context is generally contained in the form of a series of maps displaying physical and economic data. The maps generally show the location of a subject lot, competitive lots, market areas and local economy. But today's computing technology has resulted in GIS being a much more powerful and efficient way of collecting, storing, manipulating and analysing property data. The computational ability has meant that new functionalities are now available that were not previously possible with the traditional paper-and-file-cabinet GIS.

Valuation is a process requiring a whole range of analytical capabilities to handle the different analytical tasks taking place along the process; requirements range from the simple function for data summarisation to the more complex techniques involving tasks in modelling. To be of greater utility to valuation, a GIS therefore needs to support the functionalities needed to perform those tasks. In this section, we review some of the

more basic functions of GIS as applicable in valuation, look at some of related studies being conducted so far, and discuss the more complex functionalities that GIS offers for valuation.

Data Organisation

Since GIS is a methodology for the organisation and analysis of geo-spatial data, a significant benefit to a property-related organisation such as the Valuation Department of using GIS lies in the improved efficiency with which in-house property data can be held and managed. This improved performance is achieved because a GIS links data from different data-sets, including from spatial to aspatial datasets. As a simple example, suppose we need to know how many agricultural lots there are that lie from a certain kilometre distance from the town centre. The various pieces of information required to produce the answer are stored in separate files, and GIS brings them together.

The above example may seem trivial - hardly needing a GIS - but there are more complicated situations involving the different ways in which datasets need to be linked such as exact matching, hierarchical matching and fuzzy matching. A GIS can perform all these operations because it uses geography, or space as key between the different valuation datasets. Indeed, it is this ability at data organisation and manipulation that gives GIS the power to perform other complex tasks.

GIS also holds tremendous potential as a means for bringing together property-related data from disparate datasets, those that reside within external databases. This improved data availability is ideal to valuation, which always craves for access to myriad data. It certainly helps towards making automation in valuation more a reality.

Simple Query and Summary Functions

A GIS, through an appropriate software, provides the ability to display spatial data graphically. It allows a user to view on-screen a subject property together with other properties surrounding it. The view can be manipulated such that the individual lots can appear enlarged or reduced in size as desired. Also, details relating to any property can be retrieved and displayed, either textually or graphically. A GIS also allows users to perform queries of a lot's location, and of its physical characteristics such as lot size and shape. Basic statistical manipulations either of individual lots or of aggregated forms can be performed with ease.

The fact that GIS privides visual display capability is very useful to valuation. Since location is a major influence on value, GIS enhances valuation analysis by enabling the results of a database query to be displayed graphically. Simple questions of a 'what' and 'where' nature can be posed. Besides, the system allows a search to be conducted interactively with user specifying search criteria. A spatial query such as 'what is the shortest distance from a particular property to the town centre' can be easily handled by GIS.

A GIS can also be used to locate lots where certain conditions are satisfied. This function is particularly useful for seeking suitable comparables to be used in valuation. A typical problem will be one of locating a site for shopping centre where site suitability is dependent on certain criteria. The GIS, through overlay and buffer functions allows query of the database to take place.

Because a GIS is also a database, it also stores the aspatial aspect of lot data. This means

that details relating to other descriptions of property are also maintained within the system. Thus queries of such form as 'what is the plot ratio of this property' can be handled by GIS.

More Complex Tasks/Spatial Analyses

The comparable method is still an important method of valuation because every valuation must have recourse to comparable evidence ultimately. In English and North American valuation theory, this method is regarded as the most reliable method (Turner, 1977). Richmond (1986) states that "this procedure is widely adopted in practice, but requires the keeping of adequate records of transactions".

Identifying comparables and making appropriate adjustments form an integral part of valuation methodology. These are tasks that a GIS can perform efficiently. In valuation, after one adjusts for financing terms and conditions of sale to obtain the market-adjusted indicated sale price of comparable property, one must adjust for location and physical characteristics to obtain the indicated sale price of a subject lot. This process requires dealing with comparables. A GIS helps in analysing aspects of locational influences which arise in many ways in valuation. Since the value of a structure - residential, office or retail - is a function of location and linkages, a GIS is an excellent way of analysing the many complex linkages and arrive at better assessments of comparability and more accurate adjustments. A good GIS, fed with data specifying location of other lots and features such as infrastructure, can identify whether prospective comparable properties are truly comparable in terms of location and linkages. For example, in a residential appraisal situation, a comparable house may be analysed in terms of distance to shopping, schools, transportation arteries, etc. In addition, the characteristics of neighbourhood can be analysed with a GIS. Income data and other economic characteristics of the neighbourhood and surrounding neighbourhoods can be pinpointed better with a GIS than with a survey or secondary statistical research methodology.

The development of a spatial property information system allows a more explicit approach to the quantification of the effect of location. As an example, Wyatt (1995) presented a technique for using as a means for quantifying the effect of location, using accessibility as the measure; he used gravity modelling technique available on Arc/Info GIS. In that approach, the database was first searched for comparable properties. Adjustments were then made for all differences the comparables have over the subject property except for the location factor. The remaining difference in value, which could now be ascribed to location factor, was then subjected to spatial analysis. The mapping display helped in 'the visualisation of which data constitute the best comparables. In this study, the index was found to correlate significantly with the locational values of the properties.

Some of the specific valuation-related studies undertaken in which GIS was involved have included alternative scenario (what-if) analyse, study of mortgage foreclosures (Aalberts and Bible, 1992), forecast of location of development (Pittman and Thrall,1992), hedonic house price modelling (Rosiers and Theriault, 1991), site selection and location analysis (Barnett and Okoruwa, 1993), and accessibility analysis and retail gravitation modelling (Weber 1990).

Site analysis determines the ability of a site's specific physical and geographic characteristics to satisfy the operational and functional objectives of a particular land use. The focus of location analysis, on the other hand, is generally the evaluation of existing linkages. Linkage relationships develop because of the need to move people and goods between locations. In highest and best use analysis of a site, four criteria are considered namely physical supportability, legal permissibility, financial feasibility, and maximal productivity (Barnett and Okoruwa, 1993).

In another study on the application of GIS in valuation, Rosiers and Theriault (1991) considered the integration of GIS to hedonic price modelling in the Quebec region. He demonstrated how a low-cost GIS could be applied to the more complex tasks in valuation. In this study, the GIS was integrated with the RESIVALUE hedonic price model to produce the analytical capability to value property in Quebec region. The study concluded that the interpretations of complex phenomena such as spatial autocorrelation would not be possible without GIS.

This study had also shown the potential of GIS for data management and its ability to provide an analytical framework for information of a thematic aspatial nature, allowing for spatial cross-analyses of various urban dimensions. The integration was based on an open approach that creates an appropriate environment for data transfer between the many software packages involved. However, the fact that no less than ten individual small software packages need to be put together to perform the analysis would be a challenge that an average user would seriously need to consider when attempting to undertake such a task. Therein lies some value in investigating into a more modern IT environment approach that handles the same task but in a less complicated manner.

The utility of GIS in valuation can also be viewed in terms of the functionalities it makes possible but which were not possible before. The following are two examples:

a. *True distance representation.* Distance used to be stored textually in database, and was given only as an estimate based on a straight line (Euclidean) distance from a reference point. In reality, a straight line distance does not accurately portray the true state of the real world. A GIS allows true distance representation to be made by enabling actual routes to be considered in the calculation, taking into considerations the turns and bends as they occur along the routes. Through this accurate representation, the quality of the data will be improved. Moreover, data on directionality and other factors can be incorporated so as to allow the computation of estimated travelling time from point to point. Consequently, the distance factor on property value can be more accurately analysed.

b. *Trend surface analysis.* GIS enables certain techniques of spatial analysis such as trend surface analysis, kriging and triangulated irregular network to be performed efficiently. The trend surface analysis technique, a further application of regression analysis, allows identification of trends in property value which are expected to vary in strength according to their location. This results in value surface being produced. With kriging, the interest is in prediction or interpolation of property value at points where there is no sample, with the end result being the ability to make predictions.

Issues In The Implementation Of GIS In Valuation

There are significant issues that complicate the implementation of GIS in valuation. Such problems need to be seriously confronted and resolved for GIS to be successfully implemented in valuation.

Data Access

"The power of GIS technology is often said to lie in its ability to act as an integration tool, bringing together data about people, places, and environment. The problem is that the integration concept depends upon two conditions - freedom of information and geographical comparability of data" (Fotheringham, 1994). This statement is true particularly in relation to the freedom of information.

All valuation techniques ultimately rely on the collection and analysis of data; general data such as social, economic, planning and environmental attributes, and specific data including local market conditions, details of transactions such as location, physical and functional form and legal characteristics. "The validity of a final estimate depends to a certain extent on how well it can be supported by market data" (Appraisal Institute, 1992).

Access to property data for valuation remains controlled, and this control manifests in a variety of forms. Despite the recognition that data freedom is vital to improvements in valuation decision-making, data still tends to be regarded as confidential and its release is often restricted, be it in the private sector or in the public domain. Thus, a certain amount of goodwill among all data providers and government intervention are necessary preconditions for improved flow of property data.

A related problem is that, because valuation requires access to myriad data, data need to come from various sources. Data also has to be reliable and timely. This cannot take place if there is no linked database in the first place. Then there is the issue of data standard agreement that need to be resolved before free exchange of data can take place. It is in this context that the Malaysian National Land Information System (NALIS) is a step in the right direction.

Limitations of Existing GIS

The commercial software available have limited capabilities for more complex tasks in valuation. As an example, no GIS can at present claim to be fully equipped technically to undertake tasks such as multiple regression analysis, a statistical tool that is rapidly gaining recognition as a versatile tool for mass valuation. It is true that this is not a serious setback in view of the possibilities for coupling with some statistical applications. But still it does mean that such functionalities are ranged beyond the capability of users with little or no experience with the techniques for coupling the applications.

The Future

The Temporal Dimension

The GIS models which are widely in use today are atemporal - without time dimension. The state of the database at any one time represents only a snapshot of the real world and not a continuum that it really is. Since valuation is as much about time as it is about location, a time dimension needs to be incorporated into existing techniques to facilitate accurate analysis when data are obtained at a different time horizon. This will be an area in which further research is necessary. Increasingly it

will become common to store large quantities of spatial data collected at different time periods.

Expert Systems

Another major area in which research is seen for the future is in automated valuation. This requires introducing elements of artificial intelligence in a way that enables a valuation system to perform the 'learning' and self-analysis functions, and to emulate the thought processes of an expert in carrying out valuation. This trend should be interesting to observe.

Conclusions

As technology develops, opportunity grows for a higher level of sophistication in valuation analysis, and the methodology of GIS will no doubt form an important component in this opportunity. Such developments further point to what lies ahead. The full potential of these developments will not be realised unless property data become more accessible. In this respect, efforts aimed at bringing about an integration of property data are not only desirable but necessary.

Thus the NALIS initiative is a step in the right direction. The success of the initiative will depend ultimately on the commitments of the various data providers, be they in the public domain or in the private sector.

As long as location forms an important influence on property, GIS, or any land information technology for that matter – should be regarded as a major opportunity not to be missed.

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