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Studying Noise Effect on Property Valuation

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Abstract

Residential property value is a function of classical factors such as its square footage, year of construction, view and aspect, amenities, and the current market conditions determined by sales in the immediate area. Another important factor is the negative impact of noise pollutants like freeway traffic noise or schools proximity on the value of the residential properties.

Noise level is a function of distance and has an inverse relationship with residential property value. Even though noise level for each block is similar, its effect on each floor is different. This paper shows how to use 3D noise modeling and GIS techniques like Geostatistics to get a proper estimate of property values in different floors of any area.

Keywords: Property Valuation, 3D Noise Modeling ,Geostatistics ,GIS

1. Introduction

Land is a heterogeneous good that is comprised of a bundle of unique characteristics reflecting not only its location but also other amenities such as the quality of neighborhood and infrastructure. At the macro level, the understanding of the determinants of residential land value would enable policy makers such as planners to make land use allocation and taxation.

Land valuation is the process of assessing the characteristics of a given piece of land. The process may be described as a carefully considered estimate of the worth of landed property based on experience and judgment. However, the objective of land valuation is to determine value; a term generally prefaced by some description such as market value or benefit value.

In the land valuation, it is a common understanding that the value and potential of a property are fundamentally determined by its location.

Several studies assess the advantages and disadvantages of various methods for determining the changes in property values associated with proximity to a disamenity. In the empirical and theoretical property value studies, results rely on interpretations of hedonic modeling as well as alternative methods.

Hedonic price modeling is the dominant method for determining how various property characteristics affect values. Hedonic pricing is based on the assumption that amenities (e.g. square footage, access to recreational areas, or in-ground pool) have a cumulative effect on the value of the property; a greater number of amenities results in a higher sales price, whereas disamenities reduce value. Regression analysis isolates and quantifies the contribution of a single given amenity to the additive price effect. In this context, studies perform multiple regressions on the values of bundled good commodities (such as a house or commercial property) to isolate the value effect of proximity to an environmentally offensive site. The simplest, traditional hedonic study might measure only house features (e.g. number of rooms, lot size, etc.) and distance from a waste site. Thus, an indirect "cost" of an environmental disamenity is determined with respect to property values. [2]

Several studies recommend alternatives to hedonic price modeling. **Palmquist [1982]** offers a "statistically equivalent" method in lieu of hedonic regressions that does not demand extensive data collection. By examining repeat-sales data before and after environmental damage occurs, changes in property values attributable to the disamenity may be measured without multi-variable data collection. In other words, a single property with a constant set of characteristics is compared to itself over time, isolating the effect of the environmental disamenity.**Nieves [1993]** briefly summarizes the premises of hedonic modeling, "psychometric measures," and contingent valuation studies. In addition to comparing these methods, Nieves proposes a means for integrating the economic and psychometric approaches emphasized by these methods. [2]

We have grouped the classical studies into the following categories for consideration:

- Pure hedonic regressions, including the distance-from-disamenity variable and standard property characteristics.
- Studies incorporating additional variables to determine property value changes attributable to disamenity proximity.
- Studies employing methods in comparison to or as alternatives to traditional hedonic models.

Recently, Regression analysis and other advanced statistical techniques have been used to automate valuation with varying degrees of success. Automated valuation modeling (AVM) is

one of the new techniques in assessing single-property value. Based on computing model, it is recognized as a new valuation tool in the 21st century. [7]
Property Values generally reflect a wide range of amenities and disamenities available in a given community, including the potential negative values of a site. Price changes associated with proximity to a site may reflect the owners' evaluations of any or all of the following attributes: human health, ecological damage, cost of alternative water supplies, aesthetic damage, and economic effects such as changes in employment opportunities. The valuation model describes the relationship between physical and location characteristics of property, and its value. Through this study model is developed for residential property.

In the empirical and theoretical property value studies that we examined, results rely on Kriging Interpolations using geostatistical modeling as well as alternative methods. We therefore provide below a brief summary of theoretical literature for determining the 3D noise effect on property values near environmental disamenities.

2. Effective Factors on Property Value

The methodology depends on property variables (Figure 1). These can be grouped as follows: Environmental variables (neighbourhood, distance or proximity), and Property variables (quantitative and qualitative variables of the property). Some of the variables can be measured while others cannot. Variables quantification may become easier through GIS tools (buffering, overlay and modelling).

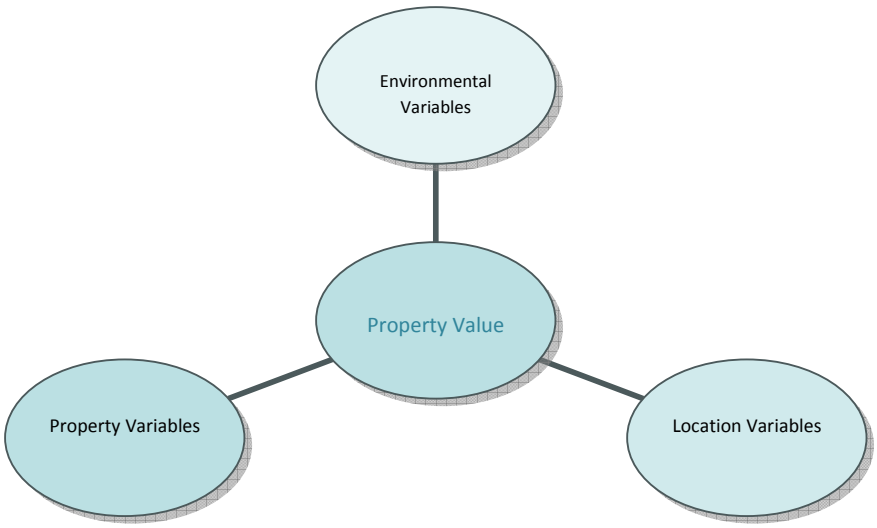

Figure 1 Taxonomy of variables

a) **Environmental Variables**

- distance from marine,distance from waterside, distance from nearest park, distance from nearest athletic club, distance from nearest recreation facility, distance from nearest school ,distance from river, distance from shopping center distance from

cemetery, level of noise (noise pollution) ,level of air pollution, view and aspect, level of commercial facilities

b) **Property & Location variables**

- Age of home, Total square meters of finished floor space, Number of bedrooms, Number of bathrooms, Number of garage spaces, Number of fireplaces, Size of lot, Housing density in neighborhood, Percent minority population in neighborhood, Median household income in neighborhood, Measure of quality of neighborhood school district, Total driving time to CBD, year of sale ,area without out of door surface ,commercial coefficient of estate

3. Noise Pollution

Human are able to hear sound within the frequency range of 20 (Hz) to 20000 (HZ). Sound is expressed in Decibels (db) & this unit used to measure the loudness of sound. The decibel is a measure of sound intensity as a function of power ratio, with the difference in decibels between two sounds being given by $dB=10 \log_{10}(P_1/P_2)$, where P_1 and P_2 are the power levels of the two sounds.

Human perception of loudness also conforms to a logarithmic scale; a 10-decibel increase is perceived as roughly a doubling of loudness. Thus, 30 decibels is 10 times more intense than 20 decibels and sounds twice as loud; 40 decibels is 100 times more intense than 20 and sounds 4 times as loud. Distance diminishes the effective decibel level reaching the ear. Thus, moderate auto traffic at a distance of 30 meter rates about 50 decibels. To a driver with a car window open or pedestrian walk, the same traffic rates about 70 decibels; that is, it sounds 4 times louder.

The effects of noise pollution are more far reaching than just hearing loss. Persistent loud sounds have been linked to headaches, stomach aches, tinnitus, irritability, loss of sleep, learning difficulties, even heart disease and high blood pressure.

Even relatively low levels of noise (55 to 60 dB) can interfere with conversation. The danger one for hearing loss begins at about 85 dB. The City Traffic noising propagation`s about 80-100db. [9]

As mentioned, Noise level is a function of distance and Highway or noisy street proximity has an inverse relationship with residential property value. Even though noise level for each block is similar, its effect on each floor is different and residents living in high rise building are also severely affected by traffic noise. It is therefore important to develop 3D noise maps that can show influence of noise in all direction and lead to better property valuation.

The best solution for measuring noise pollution is using computer software, determining crisis spots and then giving control solutions. In this way, Generation of 3D observation points that represent the virtual microphones and noise calculation using standard noise calculation models can be used. [3]

Proper estimate of property values in different floors of any area by using 3D noise map can be gained from GIS techniques like spatial interpolation methods and Geostatistics.

4. The Theory of Geostatistics

The standard GIS approach to analyzing the attributes of predefined objects implies no spatial variation within an object, and all changes occur at object boundaries. Though there are many methods for interpolation, most of these treat the data as if they can be modeled by a smooth, differentiable surface and no attention is paid to the uncertainty of the results. The methods of geostatistics use the stochastic theory of spatial correlation both for interpolation and for apportioning uncertainty. [4] Geoscientists routinely face interpolation and estimation problems when analyzing sparse data from field observations. Geostatistics has emerged as an invaluable tool for characterizing spatial or temporal phenomena. [5]

Our objective is to choose n sample locations xi, where n is fixed by resource constraints, so as to obtain the "best" predictions of the underlying signal process S(x). Recall that for any target T, we define the mean square prediction error as MSE (T) = E [(ˆ T − T) 2]. When T = S(x) for a particular location x, we write M(x) = E [{ˆ S(x) − S(x)} 2]. [Model Based Geostatistics, Springer] We consider it "Space" where univariate, bivariate, or multivariate analysis is carried out. Geographic spaces are in 1-D, 2-D or 3-D. [1]

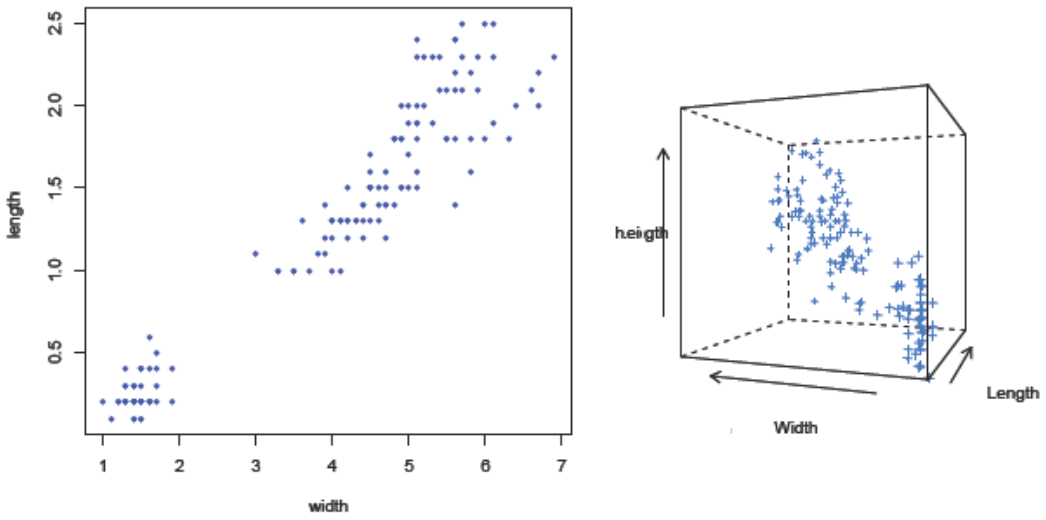

Figure 2 2-D and 3-D spaces [6]

4. Methodology

The most important operation to proper property valuation is capture suitable and sufficient data in study area. These kinds of data are Property market value, total square footage, building square footage, number of rooms, Age of property, Noise level around the property, etc.

In order to reach 3D noise maps, 3D cadastre or 3D city model will be need. In some cases, having the buildings and floor's height are enough. This height helps us to arrange 3D observation points to reach noise maps. The observation points represent location of virtual microphones or any other kinds of powerful sensors where the noise levels are to be calculated. The scale and density of the observation points should be sufficient enough and at least two points in each floor to reach adequate accuracy in the final results. There is no standard for spacing of observation points and it's also depends on each floor's height. These observation points have a known coordinate with the noise level can be finding in two ways. The first way is using the high accuracy sensors to gain noise level in the known points in decibel unit and the second is virtual microphone to gain the noise levels are calculated based on the input traffic data. [3]

Some institutes like Air quality control or Traffic control organization have the powerful instruments to gain noise level in each point. After calculating the noise levels of each observations points, GIS techniques likes interpolation or Geostatistics, helps us to produce 3D noise maps in study area. 3D noise maps led us to better understanding the noise distribution in each floor and the different level. This paper's procedure of noise effect on property valuation is shown in figure 3.

For consideration of relationship between parameters like noise and distance from freeway we used multivariate regression analysis (multi regression analysis). The market value of the residential property (MVR) was the dependent variable although other residential property variables are independent. We stepwise added the related variables to the primary regression model and developed it. First variable was the most correlated property variable, total square meters of finished floor space (TSQ). The model is the form below

$$\ln Y = a + \Sigma (b_i \times X_i)$$

where Y is the dependent variable; a is the regression constant; bi is the value rating for the independent variables; Xi represents the independent variables. [8]
To test whether the independent variables selected in this stage are suitable for explaining the generally circumstance, several model created and we received that with considering the effect of noise in urban area property value is more accurate. For comparison we test 3 models first by considering property variables together (PV), second adding effect of noise (NE) and finally putting location variables (LV) into the model.

5. Results

Table 1 provides the best model data that we tested for exploring the effect of noise. It has the largest R square near to 1 and the minimized standard error of estimation. It is obvious from the table below that by considering the noise effect we can then be more accurate and the model is reflects the reality of urban and environmental factors affecting the property value.

Table 1 results

Model	R square	Standard error of estimation	Model variables
Model 1	0.72	0.0983	PV
Model 2	0.83	0.0687	PV, NE
Model 3	0.89	5.35E-2	PV, NE , LV

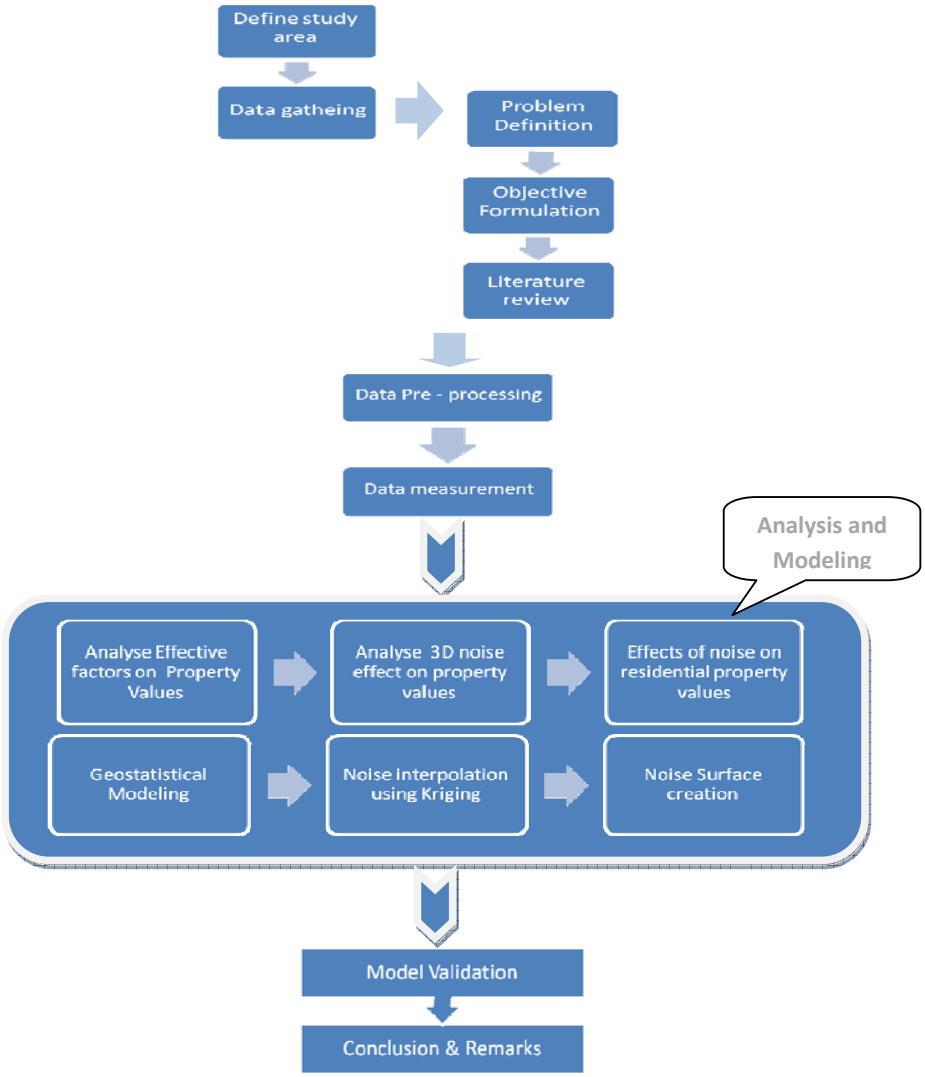

Figure 3 Noise effects on property valuation methodology

6. Conclusion

Land value research can be conducted at several levels of analysis. It can range from aggregate or regional analysis to the study of price determination for a particular parcel of land. Planners are generally interested in determining land prices in order to better formulate taxation policies, regulate urban land markets and growth pressure, enable integrated development, and allow communities to share in the appreciation of land values that usually accompanies urbanization.

Through regression statistic analysis and spatial analysis in GIS, the study has confirmed and measured out the influences of the main variables on the spatial characteristic of the urban residential land values. In the sense of main variables, we study the effect of noise on property values.

The primary finding of this study was the negative relation between the market value of a property and the noise level emitted from the nearby highway or noisy streets and attend us that noise level is different in each floor and has a different effective on property valuation. The study will be helpful for improving the land valuation thus make the land market more efficient. In urban planning finding the effects of environmental variables helps decision makers for better guidance of urban development plans and infrastructures.

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