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Fuzzy effects of urban landscapes on land prices

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Abstract

In this paper, we deal with the effects of urban landscapes on land prices under uncertainty, represented by fuzzy numbers. To this end, the factors for evaluating urban landscapes are designed using fuzzy numbers. Moreover, we consider 11 factors for utilizing the approach, like as Continuity of external walls, Conformity of colors and materials, Favorable pedestrian space, Decorations and street furniture and etc. Then, two fuzzy hedonic approaches are applied to examine if the essential components of urban landscapes were significant determinants of land prices. Finally, we propose a pessimistic/optimistic approach for analyzing and extracting the relation between effects of urban landscapes on land prices. To the best of our knowledge, this is the first time in the literature that such effects are examined on the land prices under fuzzy numbers.

Keywords: Urban landscapes, Land price, Fuzzy number, pessimistic/optimistic solution;

1. Introduction

There exist a few frameworks for evaluating landscapes in urban contexts Lichfield [5], Carter and Bramley [2], Coeterier [3] analyzed the values of historical sites and traditional dwellings with respect to physical space and compositions. In [6], Gaoa et al. proposed a framework to resolve the evaluations of urban landscapes, especially in built up area which are often a mixture of personal views. So, they have suggested an objective methodology and have developed a formal procedure for landscape evaluation. Also, data from the cities of Tokyo and Kitakyushu were used which are typical of large metropolitan area and medium-sized cities in Japan. In this contribution, we try to extend Gaoa et al.'s procedure under usage of fuzzy concepts. Fuzzy set theory [7] has been applied to many areas which need to manage uncertain and vague data. Such areas include approximate reasoning, decision making, optimization, control and so on [4, 8]. This paper is organized as follows:
In Section 2, fuzzy landscape survey is given and in section 3, the principle components analysis under fuzzy setting are provided. To this end, the data of two cities are examined which is fuzzified under personal view. Also, some discussion are given in Section 4 and the paper ends with Conclusion.

2. Fuzzy landscape survey

In this section, the proposal of Arai [1] was used for reference, i.e., to evaluate urban landscapes in built-up areas from three aspects: neighborhood scene, street scene and the practice of local-based planning which are converted to fuzzy numbers. An 11 fuzzy factor evaluation system was designed as following such that the fuzzy factors beginning with 'A' are indicators of neighborhood and those with 'B' are indicators of streets. Every fuzzy factor consists of three cases as pessimistic/optimistic and intermediate where the pessimistic and optimistic are derived from support of related fuzzy numbers and the intermediate is derived from core of fuzzy number:

A1: Continuity of external walls (0;1):
- walls are well-aligned along streets to a high degree (optimistic:+1)
- walls are well-aligned along streets to an average degree (intermediate: 0)
- walls along streets are not continuous (pessimistic:-1).

A2: Conformity of colors and materials (0;1):
- colors and materials of buildings are in harmony to a high degree (optimistic +1),
- colors and materials of buildings are in harmony to an average degree (intermediate 0),
- colors and materials of buildings are not in harmony (pessimistic:-1).

A3: Compatibility of building styles (0; 1):
- Building styles share common features to a high degree (optimistic:+1),
- Building styles share some kind of common features (intermediate: 0),
- Building styles have little in common (pessimistic:-1).

A4: Beauty of skylines formed by buildings (1;2):
- Building heights are orderly and under control +1,
- Roof shapes are similar +1,
- Rhythms of skylines are beautiful +1,
- Silhouette of buildings distinctly lacks order -1.

A5: Openness and scale of buildings (-0.5;1.5):
- Spaces formed by buildings are open and comfortable +1,
- Street spaces are narrow and compressed -1,
- Open spaces are dull and without change -1.

A6: Visually aesthetic and continuous greenery (1;1):
- Greenery in the district forms a network +1,
Greenery is visually continuous +1.

**B1: Greenery of walls and trees (0;1):**
Walls along roads are continuously greened +1,
Walls along roads are greened to an average level 0,
Walls along roads are mostly concrete blocks -1.

**B2: Greenery of open pedestrian spaces (0.5;1.5):**
There are well-greened parks and playgrounds +1,
There are abundant trees along the streets +1,
Land is deserted and garbage is scattered throughout it -1.

**B3: Favorable pedestrian space (-1;2):**
Streetscape is rich and pleasant +1,
Street scenes are chaotic with garbage bins, bicycles -1,
Advertisements are in disorder -1,
Illegal parking hinders pedestrian use -1.

**B4: Friendly outdoor space (0;1):**
Street spaces are friendly and sociable +1,
Streets spaces are isolated, without living atmosphere -1.

**B5: Decorations and street furniture (1;1):**
The there is street furniture, sculptures, waterscapes, etc. +1,
There is well-designed lighting, etc. +1.

Please notice that, for cases A4 – A6 and B1 – B5, the extreme points are given instead of using pessimistic/optimistic phrase. Since, the conditions did not consider as high level to low level and just are used as additional cases.

3. **Principal component analysis of fuzzy landscape data**

   It was found that the ratings of the 11 landscape indices were inter-correlated. In order to analyze the evaluation structure better, the correlation problem has to be addressed. Therefore, a principal component analysis was performed. For the Tokyo data, the 11 factors were first grouped based on the intensity of their correlations. With a graphical modeling method, they were classified into four categories:

   (1) A1 (continuity of external walls), A2 (conformity of colors and materials), A3 (compatibility of building styles), and A4 (beauty of skylines formed by buildings);

   (2) B1 (greenery of walls and trees), B2 (greenery of open pedestrian spaces), and A6 (visually aesthetic and continuous greenery);

   (3) B3 (favorable pedestrian space), B4 (friendly outdoor space), and A5 (openness and
Notice that, such concepts are considered as fuzzy numbers, particularly, triangular symmetric fuzzy numbers. It is easy to see that such concepts in deterministic cases are given in [6].

3.1. Fuzzy hedonic analysis of landscape factors in Tokyo

Here, we apply the fuzzy hedonic analysis. In fuzzy hedonic pricing models of land prices, the principal components of urban landscapes were used as independent variables to see if they had significant impacts on land prices. For the Tokyo sample, the following fuzzy linear regression function was employed:

$$unitP = \text{intercept} \cdot \sum \alpha_i X_i \cdot \sum \frac{b_j X_j}{S}$$

where unitP is a vector of the per-square-meter price of land, $X_i$ (for $i=1,...,m$) is a vector of the $i$th independent variable, $S$ is a vector of lot size, and $\alpha_i$ and $b_j$ are fuzzy regression coefficients to be estimated. The terms $X_i$ and $X_j/S$ were included in the model together, assuming that the influence of some variables might differ by lot size $S$.

**Remark 4.1.** Please notice that, this model in deterministic case is proposed in [6]. We derive the fuzzy regression coefficients using extension principle.

3.2. Fuzzy hedonic analysis of landscape factors in Kitakyushu

A modeling procedure similar to the one described above was followed using the Kitakyushu data. As a result, a log-linear regression model for per-square-meter land price, unitP, was established:

$$\ln(unitP) = \text{intercept} \cdot \sum a_i X_i$$

where $X_i$ (for $i=1,...,m$) is a vector of the $i$th independent variable, and $a_i$ is the fuzzy regression coefficient. The signs and the estimates of the variables were consistent with expectations. In this model, two principal components of landscape factors, compatibility and greenery were significant.

4. Discussion

The average land price levels of the Tokyo and Kitakyushu samples were 602.4 and 73.2 thousandYen/m² (5238.3 and 636.5 US/m²) in the deterministic case. But, we considered these averages as (602.4; 10) and (73.2; 4), respectively. This means compatibility or greenery marginally accounts for [0.5,2] percentage of the total prices in Tokyo, and more than [1.5,4]
percentage in Kitakyushu. In absolute values, the impacts of compatibility and greenery were $(7.2; 4)$ and $(8.0; 55)$ thousand Yen/m$^2$ in Tokyo, and $(2.23; 0.1)$ and $(2.45; 0.14)$ thousand Yen/m$^2$ at the average land price level in Kitakyushu. These results were reasonable for both cities. In terms of the amount, the influence of landscape amenity on land price should not be ignored. Please notice that, using fuzzy numbers instead of real-valued number is common sense, since the personal view is so effective for reports.

5. Conclusion

For supporting decision-making in landscape management and planning policies in urban built-up areas, a formal framework is proposed to evaluate urban landscapes objectively represented by fuzzy numbers. Data from the cities of Tokyo and Kitakyushu were used and also fuzzified based on the personal view, which are typical of large metropolitan areas and medium-sized cities in Japan. The results have shown that the compatibility of the buildings and the greenery of the neighborhood were distinctively perceived; these factors significantly influenced land prices, and the marginal effects were similar for both cities even in the fuzzy literature, since these are valid in deterministic case [6].

References