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Urban Transformation Measures: Interpolation of Land and House Prices in Istanbul

Abstract

Although one of the most important factors that affect housing market is land price, its affect has not been widely investigated in the literature. However, land values have remarkable affect on construction costs which has great importance for the supply responses to increasing housing demand. Therefore, this paper raises two main questions to search. The case area for the investigation is Istanbul. The former question is: do land prices contribute the variance in house prices? This question is tested by interpolation technique in Geographic Information Systems (GIS) in order to reflect whether the highest house prices are recorded for the high land price regions of the Istanbul or vice versa. Interpolation technique provides to estimate spatially correlated variables and to visualize this spatial correlation in a continuous surface. Of all interpolation techniques, kriging method is utilized in this paper to generate estimations with the data of both land and housing prices at sampled locations.

The latter question is: how do land prices affect the emergence of a local market? Researches show that an increase in land prices may cause the potential decrease in housing supply while the decrease in land prices may have positive influence on its supply. By applying geographic weighted regression, it is examined whether land and house prices are in consistency. It is assumed that in regions where land prices help to explain house prices moderately, the other properties are in poor condition. On the contrary, at areas where land prices explain house prices inefficiently, other properties are relatively in good conditions. By following the first assumption above, the areas corresponding to the assumed situation are recommended as residential transformation areas in Istanbul. Property values are low in these kinds of areas, so their exchange values attract developers to invest these areas.

Keywords: housing markets, land prices, house prices, kriging, geographic weighted regression, Istanbul

1 Introduction and Related Literature

The neoclassical paradigm emphasize that a real estate market is assumed to be efficient, well-functioning and equilibrating entities much like the hypothetical market depicted in the perfect competition model (Leishman, 2003). However, this definition puts the main difference between real estate markets and the emphasized perfect competition theory at the same time.

It can be generally said that, different from the perfect competition theory, real estate markets are divided into a number of sectors one of which is residential sector. To an extent, there are several sub-sectors defined in the case of residential sector. This leads us to consider the housing market with its sub-markets. Traditional definition of housing submarkets have been understood in terms of the attributes of housing stock (type of dwelling, type of tenancy and price), household type (family status, economic status and ethnicity) or location. Additionally, housing markets could be the spatial outcomes of land use changes, occupancy patterns, social area changes, housing prices and housing quality (Clark, 1982; Leishman, 2003; Knox and Pinch, 2006).

Housing is a composite good and its demand is thus derived from the demand for its component attributes. As emphasized formerly, its component attributes define the heterogeneity among sub-markets at any one time. Every property is fixed in terms of location and furthermore that only one property can occupy an exact given location. This suggests that, at the level of individual property, location may be an important determinant of price or value. The spatial fixity of supply and the partly location-specific nature of demand are of particular importance to a micro-level consideration of real estate markets. Indeed, these factors are a primary determinant of what may be termed 'local markets' (Leishman, 2003).

In such a context, the question comes in fort is that in terms of local market definition, what is the role of land price? Further explanation; is there a positive linear relationship between house prices and land prices? For instance, is it expected that house prices are inherently higher in areas at where land prices are relatively high according to remaining areas. In other words, how do land prices affect the emergence of a local market?

What could be the practical contribution to examine the delineated research question? In case of getting a 'no' response to the research question, in other words, if there exist areas where land prices are high but house prices are relatively lower, or reversely, if there exist areas where land prices are low but house prices are relatively higher, this will reflect local markets that are not basically defined depending on land values. However, it is expected that land rent is typically highest in and around central areas or decline to zero at the urban fringe related to transportation cost. Therefore, if land and housing values are not in consistency, there may be some other factors that impact on emerging housing markets.

Certainly, the definition and determination of housing sub-markets in an urban area could be done not only considering land values but also including in many other properties of housing such as physical properties, locational characteristics and environmental conditions. However, in this study by ignoring all the other properties, it is focused on only land price. The main reason of that is putting residential transformation areas across the Istanbul clearly. Since the aim of the study is not to analyze housing sub-markets structure, but, to put housing sub-markets consistent with residential transformation areas, it is restricted with land prices. Therefore, it is expected that the results of research question will direct to us to define housing sub-markets under two domains (1) housing submarkets that could be defined as residential transformation areas and (2) housing submarkets that could not be defined as residential transformation areas.

By explaining housing sub-markets depending on only land prices, it is assumed that (1) at areas where land prices help to explain house prices moderately; housing properties, locational characteristics or environmental conditions are relatively in poor conditions. (2) at areas where land prices explain house prices inefficiently; housing properties, locational characteristics or environmental conditions are relatively in good conditions. Literally, since the other properties are in poor condition, the land price is sufficient enough to explain the housing price in the former, reversely, the land price is not sufficient enough to explain the housing price in the latter because the other properties are relatively in good conditions. Therefore, by following the first assumption above, the areas corresponding to the assumed situation are recommended as residential transformation areas in Istanbul. Property values are low in these kinds of areas, so their exchange values attract developers to invest these areas. However, the areas corresponding to the second assumption could not be interpreted as residential transformation areas because of the high property values.

Since the research focuses both the spatial distribution of land prices and house prices and their coincidence across space, examination is done by applying geostatistical analysis techniques. GIS, combined with interpolation and geographic weighted regression techniques, is used to perform clustering and investigation of housing sub-markets in Istanbul where the conventional statistical analysis cannot properly explain the spatial pattern.

Distinct from usual data analysis (like statistical methods), spatial analysis is a set of methods, the results of which may vary when the geographical locations have been varied. Tobler best defines the main principle of Spatial Statistics and Analysis as the first law of geography: “everything is related to everything else but near things are more related to each other” (Tobler, 1970). Among spatial analysis techniques, geostatistical analysis and interpolation techniques, have gained importance as one of the exploratory spatial data analysis applications in GIS. Interpolation technique is generating a continuous surface by the use of sampled data with the rules and functions of spatial autocorrelation. As the central aspect of spatial analysis and geostatistics, spatial autocorrelation is indicated with the degree of similarity of values of a regionalized variable over an observed sampled data (Griffith, 2003). Consequently, by means of interpolation technique, spatial pattern can be interpolated providing not only easy-to-use and effective tools for data display and visualization but also up scaling and generalization functions in environmental modeling (Burrough, 2001).

Two methods are used in this paper: Kriging and Geographic Weighted Regression. Kriging is an optimal linear unbiased spatial prediction or interpolation method. The start point is a decomposition of spatial variability into large scale trend and small scale spatial autocorrelation. It provides an optimal predictor for values in continuous surface by the use of observed sampled data and by introducing the accuracy test, the self-consistency is checked. As a conventional statistical analysis, regression analysis assumes the data to be constant over space. As an exploratory tool in GIS, Geographically Weighted Regression (hereafter, GWR) allows the modeling of processes that vary over space and investigate the spatial variations different across space (Charlton and et. al, 2006). The results of GWR can be mapped to produce continuous surface, interpolating the spatial data gathered from the entire study area. Most common applications in GWR are the studies of real estate markets, in ecology to examine spatial changes between species richness and environmental drivers (Foody, 2005), in epidemiology (Nakaya et al, 2005), and other case studies developed mainly by the research group that first introduced this methodology (Fotheringham et al, 2002). Briefly, GWR contributes on the nature of the processes of spatial data and take the place of traditional statistical analysis, especially regression analysis.

2 Methodology

The data of the study comes from two sources. Housing prices are gathered from the asked prices from a weekly published real estate supplement of a national newspaper (Hürriyet Emlak; 2009) over the period of May to June 2009. The data reflect the prices of 1172 houses across the Istanbul. Spatial distribution of the data is limited with the offer of the real estate supplement of the newspaper (Figure 1.). This collected housing price data is inserted into GIS database by joining with the land price values. Land price data is gathered from the Istanbul Metropolitan Municipality in 2002.

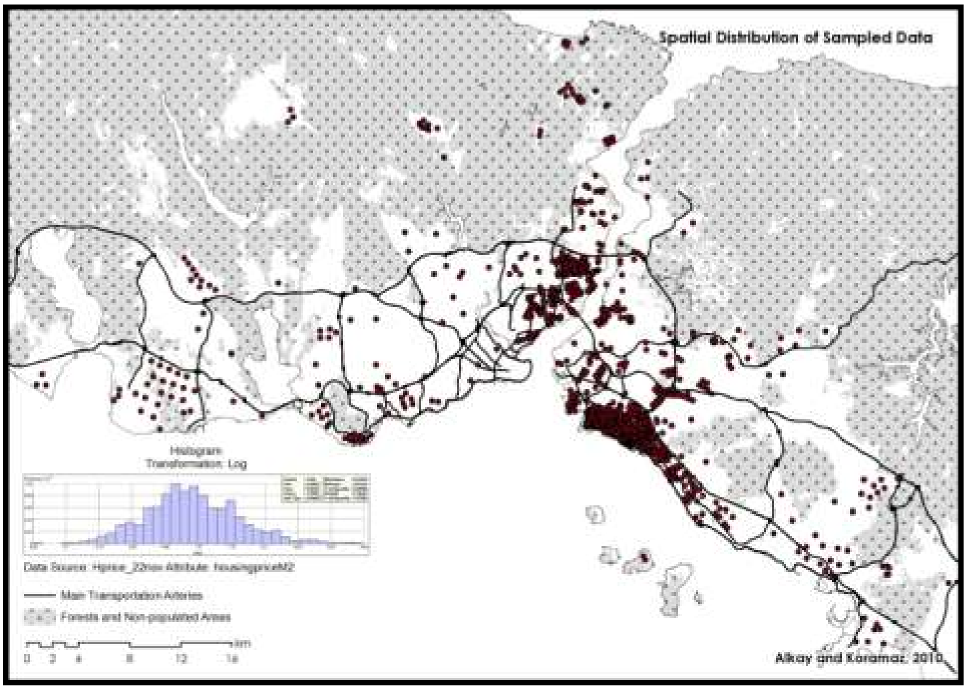

Figure 1. Spatial Distribution of Sampled Data

As emphasized in the introduction, the paper investigates the relationship between housing and land price values to determine the housing sub-markets in a broad sense and residential transformation areas as a representative of a sub-market in a narrow sense. Investigation is done with two different analyses of which are developed by means of geostatistical analysis techniques by means of GIS. The first analysis is to interpolate the spatial pattern of housing price in Istanbul on continuous surface. The aim of the first analysis is to examine whether the highest house prices are recorded for the highest land price regions of the Istanbul. The second analysis is GWR which is conducted in three steps. In the first step, regression analysis is conducted with a dependent variable of housing price and an independent variable of land price. In the second step, the relative predictive performance of regression analysis is tested by the help of the standard residuals generated from geographic weighted regression. In the last step, the local variations of standard residuals are interpolated in order to identify areas where the land price has a remarkable impact on housing price. These three steps are taken in order to examine whether land and house prices are in consistency or reflect an obvious pattern in terms of inconsistency.

As one of the interpolation technique, Kriging is applied for developing the first analysis. Proposed methodology comprises the spatial interpolation of actual data for housing price in Istanbul. Therefore, housing price is modeled in a continuous surface across Istanbul regarding to the sampled data. Before the utilization of Kriging interpolation technique, actual data has been checked whether the data set reflects the inherent characteristics of normal distribution. By considering each variable's distribution characteristics (the distribution of a variable is not symmetrical about the median or the mean; each of them reflect positive skewness; each of them are leptokurtic), logarithmic transformation is applied to data set. After logarithmic transformation, as could be followed from the histogram on Figure 1, the data set appears to be close to a normal distribution (*mean: 7.2952; median: 7.2633; skewness: 0.3341; and kurtosis: 3.4114*).

In the production of the interpolation map, GIS with geostatistical module provides calculated statistics in terms of cross-validation, in order to generate predictions as close as to actual values (Fuentes, 2002). Several interpolation techniques with changing functions (such as semivariogram surface and defining neighbourhood in interpolation) are tested with these calculated statistics. As the best performing, exponential universal Kriging interpolation model is chosen for prediction of spatial variation of actual housing price value (*mean prediction error: 0.0021; root-mean-square: 1,129; and root-mean-square standardized prediction error: 1.903*) (Figure 2). In order to test whether it is generated accurate predictions, some main parameters that are outcomes of the interpolation should be checked. Constantly, mean prediction errors (*to be close to zero*), root-mean-square (*to be smallest as possible*), and root-mean-square standardized prediction error (*to be close to 1*) are expected to reflect the delineated figures in parenthesis. When the results of the interpolation model are evaluated, it may conclude that interpolation model reflect a good accuracy.

Figure 2 shows the spatial distribution of the changing levels of housing prices per square meters in Istanbul according to interpolation model. The interpolation map indicates clearly the distribution of housing price values from low to high across space. The higher interpolation values correspond to the higher housing prices. The distribution of the interpolation values emerge three distinguished housing markets in Istanbul: (1) the coastal region of Bosphorus and the surrounding area of new central business district, (2) peripheral housing development for high income households, and (3) unclassified housing settlements.

The first market is located along Bosphorus. Specifically, Arnavutkoy, Bebek, Emirgan, Beylerbeyi, and Kanlıca are the places where housing prices are the highest at this region. Also, Levent and Maslak accomodate the highest price housing areas as the new central business district of the Istanbul. Settlements stated in the second group are either located along Marmara Sea or along the main transportation arteries of the city. Housing prices of this group are lower than the housing prices of the first group. Florya, Yesilkoy, Moda, Goztepe, Erenkoy, Suadiye, Bostanci are examples of housing areas which are located along the Marmara Sea. Atasehir and Bahcesehir are examples of housing areas which are located along the main transportation arteries of the city. Although, Florya, Yesilkoy, Moda, Goztepe, Erenkoy, Suadiye, Bostanci are older housing areas than Atasehir and Bahcesehir, they were all peripheral housing areas in the development process of the Istanbul. However, nowadays, they are almost situated in the middle parts of the city. Settlements stated in the third group reflect some different characteristics within the group. For instance, some of them are unplanned housing development areas like Sultanbeyli, some of them are old squatter areas like some parts of the Eyup and Kagıthane, some of them are industry dense housing areas such as Bayrampasa, Bagcılar, Gungoren, and Pendik and some of them are historical housing areas like some parts of the Fatih and Eyup. Housing prices of the third group is the lowest among the others.

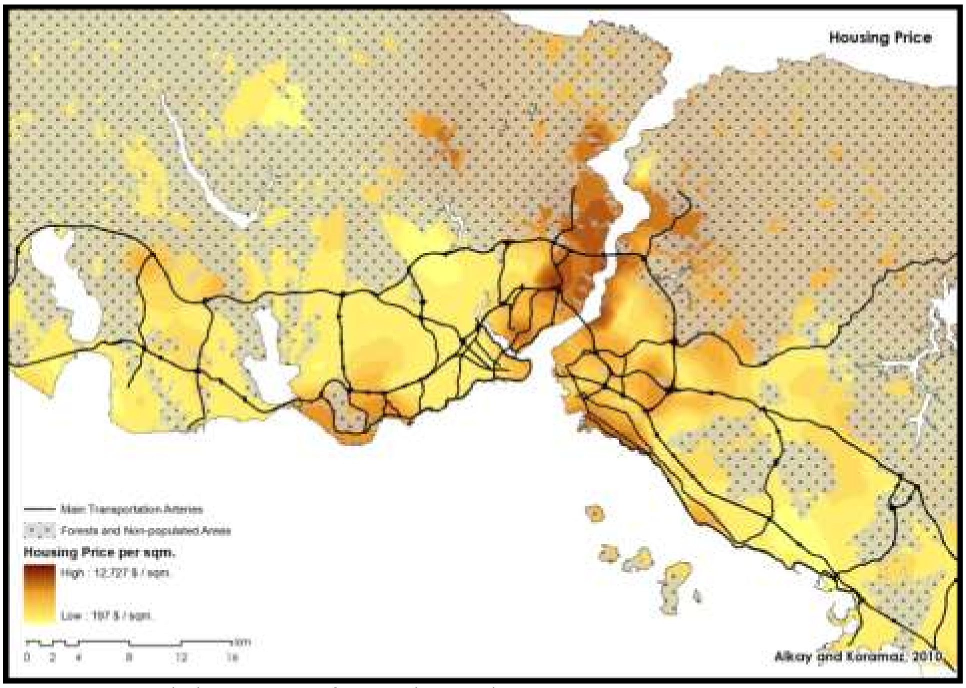

Figure 2. Kriging Map of Housing Price

Another analysis is applied for land values in order to make capable of comparison between the spatial distribution of housing and land prices. Figure 3 shows the spatial distribution of land prices per square meters in Istanbul. The highest land prices (the dark blue colored areas) can be followed in Acıbadem and Altunizade at where a new central business district has been developing and Kanlıca which is located at the Bosphorous. Although the land prices are the highest at Acıbadem and Altunizade region, the house prices are about average according to Istanbul distribution (Figure 1). The first group is followed by Florya, Yesilkoy, Atakoy, Moda, Goztepe, Suadiye all of which are located along the Marmara Sea (the light blue and dark green colored areas). As emphasized, all these areas have high housing price values. Additionally, some parts of the Bosphorous like Bebek, Arnavutkoy, Salacak, Kuzguncuk, Beylerbeyi have moderate land values, however, all of these areas have located highest value housing areas. Although some parts of the Besiktas and Sisli reflect high land prices, these areas are not totally included in the new central business district development area. As remarked, the new central business district and surrounding areas are accommodated the highest value housing areas. Some parts of the Bosphorous and some parts of the Marmara Sea costs reflect moderate land values. Most of the historical parts of the city or some unplanned and old squatter areas show moderate values also. In summary, it can be obviously said that the old central parts of the city, new central business development areas, coastal regions and older housing areas of the city are relatively higher land values than the other parts. Land values of the other parts are lower than average value and generally located along main transportation arteries and the long distance areas from the central parts.

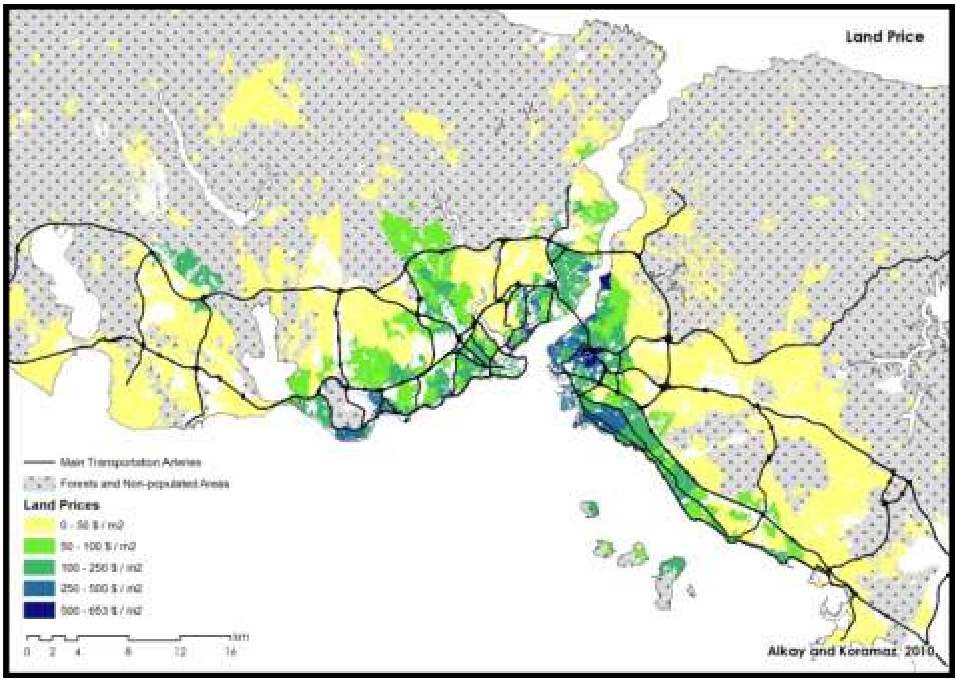

Figure 3. Land Price Map

After getting housing and land price maps in order to make some comparisons between spatial distributions of them across the city, the second step is applied. In the second step, using the GWR tool in the Spatial Statistics Module in ArcToolbox, a spatially calibrated model is generated in order to estimate the relationship between housing prices and land prices. The GWR tool gives regression coefficient and standard residual for each of the 1172 houses in the sample. In the model, housing price per square meter is used as a dependent variable. It ranges from \$197 to \$12,727, with an overall mean of \$1,784.27 and median value of \$1,424. Land prices per square meter is an independent variable and ranges from \$5.83 to 510.71, with an overall mean of \$216.35 and median value of \$232.20 (Table 1).

Table 1. Variables with basic descriptive statistics

VARIABLES	Mean	Median	Std. Dev.	Minimum	Maximum
Housing Price ($)	321,210.37	205,855.44	395,099.91	27,447	5,000,000
Housing Price per sqm ($)	1,784.27	1,427.00	1,338.57	197	12,727
Land Price ($)	216.35	232.20	119.13	5.83	510.71

The GWR model is functionalized with the following equation:

$$y_i = \beta_0 (u_i , v_i) + \beta_1 (u_i , v_i) x_1 + \varepsilon_i \quad [1]$$

Where y_i is the value of housing price per square meter at location i; β_0 is the constant term; x_1 is the value of land price per square meter at location i. β_1 is the value of coefficient and ε_i is the residuals. In this model, the coefficient varies depending on the geographical coordinate of the location as (u_i, v_i).

The overall R^2 (0.295) and adjusted R^2 (0.280) values of the model are acceptable. The values of standard residuals vary from –1.666 to +8.489. These standard residuals are supposed to be sum of the predictors which are omitted in the estimation process of the model. Consistent with the purpose of this paper, standard residuals from GWR model are mapped as raster surfaces by applying universal Kriging method to examine whether land and house prices are in consistency (*mean prediction error: 0.000884; root-mean-square: 0.9552; and root-mean-square standardized prediction error: 1.137*). Figure 4 illustrates Kriging interpolation map involving the standard residuals from GWR model.

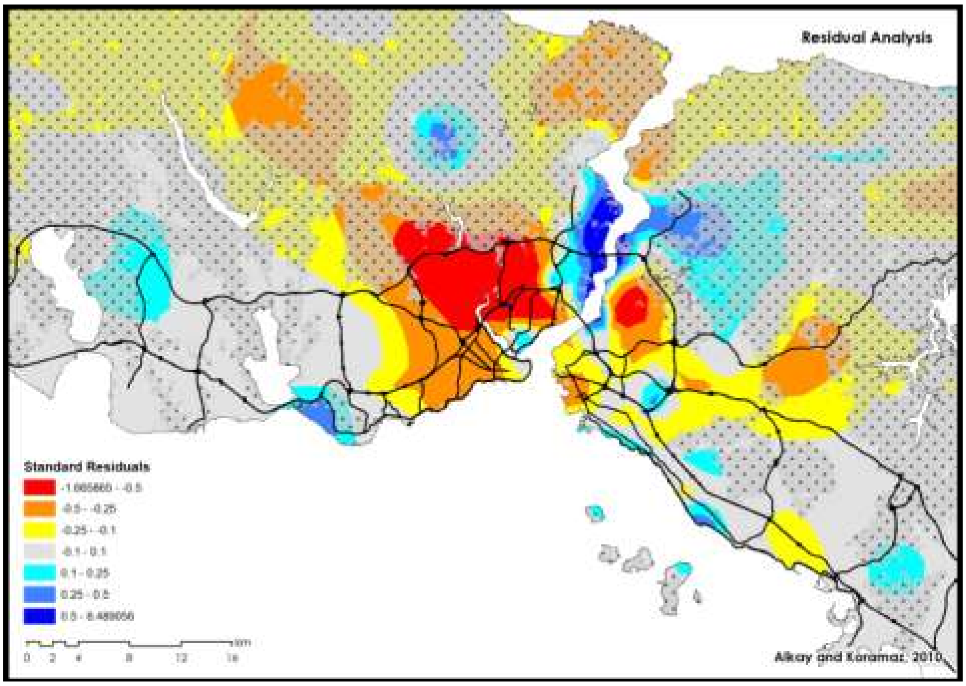

Figure 4. Residual Analysis

Blue colored areas in the interpolation map reflect the standard residuals are in positive sign whereas the areas in yellow, orange and red reflect the standard residuals are in negative sign. When the values of standard residuals are increasing in both positive and negative sign, it is assumed that land price is insufficient to explain the variance of housing price. On the contrary, the areas where standard residuals are getting close to zero are interpreted as land price is moderately explaining the variance of housing price.

Because the housing values are remarkably higher than that the land values, standard residuals are in positive signs and varying in a wide range in blue areas. Therefore, housing price is not explained moderately only depending on land values. Other factors such as physical factors, quality, accessibility and environmental conditions should be considered to include in the equation in order to make precise estimation. When considering the whole parts of the city, it is expected that housing conditions are relatively better than that the remaining neighborhoods in these areas. Moreover, considering the locational advantages, the environmental quality of these areas are expected to be higher than that the other parts. Therefore, related to the high use values and high property values, the exchange values are also high in these areas which mean that these areas are so valuable to be residential transformation areas.

Since variation is lower in yellow, orange and red areas, housing values are remarkably lower than that the land values. Additionally, because house values are explained moderately only depending on land values, it is expected that housing conditions are worse in this areas. The use value of housing is defined as the net utility of housing properties, surrounding environmental conditions and access to services such as educational, medical and leisure services. By structuring an environmental quality index for housing areas across Istanbul, Alkay (2009) shows that environmental quality is the lowest in these areas with low property values. Most of the yellow, orange and red colored areas of this study are merged with housing areas where the environmental quality index values are the lowest (Alkay, 2009). Therefore, these areas at where lands values are high but housing values are low could be interpreted as possible residential transformation areas of Istanbul.

What could be the possible effects of these transformation areas on Istanbul's housing market? The needs and aspirations of different socio-economic groups are matched to particular types of housing through a series of different market arrangements. In some inner-city neighborhoods, the deterioration of the housing stock has reached the stage where landlords can find no buyers and so are forced to abandon their property altogether. Since these residential transformation areas have a housing stock in poor condition, and there are lacks of some locational and environmental opportunities, it is expected that these areas has been going on being a kind of deteriorated areas. This will decrease the attractiveness of these areas for investments. This deterioration has itself led to a further depletion of the privately rented stock in many inner-city areas. However, transformation projects will have a huge influence on the capacity of any local economy to attract investment (Guy &Henneberry, 2002). Consequently, in such a context:

1. Transforming these areas could be increase use value of the properties
2. The use value of housing will be a major determinant of its exchange value in the market. Therefore, transformation of these areas may increase the exchange value of housing (Knox and Pinch, 2006)
3. It may prevent further deterioration of the housing stock
4. It may improve housing quality in the short run
5. It may encourage new investments to these areas by increasing the privately rented stock in these areas at the same time

On the other hand, transforming these areas could be emerged some disadvantages especially for low income families. It is expected that these areas could be resulted in low-income families spend a larger proportion of their income on housing because of higher rents as a result of transformation. Also, transformation may destroy neighborhoods while eliminating deterioration so may low-income housing. The other expected impact on low-income families is that it may trigger the filtering process. Transformation not only changes the character of a dwelling or improves the environmental quality of a housing area, but also changes the rental values of the area. If the newly available units after transformation are too expensive this means that low-income households will be filtered down. Therefore, while developing policies for transformation the attention paid not only increasing the attractiveness of the area for investments and improving the local economic capacity, but also avoiding making the poor worse.

Conclusions

In this study, the residential transformation markets are investigated constituent with housing and land prices. By estimating the housing price depending on the land value, it is aimed to get responses to the questions below. Is only land value capable of explaining housing prices? What does this mean if it is moderately explain the housing price for the definition of housing submarkets in a city?

Applied analysis technique, Kriging, provides opportunities like offering spatial distribution of housing values as continuous surface across Istanbul. Therefore, it is capable of measuring values distributed across space; in which parts values explain housing markets or vice versa. Further, estimating the housing price depends on the land value by applying GWR show areas exactly at where land prices explain house prices moderately or vice versa.

Analysis results reflect that land prices and housing prices change consistently in most part of the city. Spatial variation of both housing and land prices are resulted in heterogeneity in housing market structure in the city. As a natural result of this situation, GWR estimation puts that while land values are enough to explain housing prices in some places; this is not realized in the remaining parts. Consequently, estimation result reflects the obvious housing sub-markets consistent with land prices. Among these sub-markets, the areas where land prices explain housing prices better than the other parts are interpreted as residential transformation areas of Istanbul. Determination of the spatial distribution of these areas may help politicians and practitioners to prevent the further deterioration of these areas and to attract investment for improving housing environment.

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