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RECONSTITUTE SPATIAL WEIGHTS MATRIX CONSIDERING U-CITY NETWORK STRUCTURE

SUNGHWAN KIM[1], KABSUNG KIM[2*]

[1,2,3]Yonsei University, South Korea

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Abstract. In this study, we reconstitute a spatial weights matrix for U-City Network Structure and construct a regression-based spatial analysis model among 16 major administrative areas. Existing spatial weight matrices for spatial autoregressive models commonly consider adjacency or invert distance weighting. However, nowadays, a virtual network system is more important than actual distance to reveal spatial dependencies. Especially in Korea, U-City(or smart city) network structures have expanded rapidly by the government and reconstructed traditional urban systems. The most characteristic point from advanced research is that we consider the U-City network structure into the spatial adjacencies and interactions model. This result in a family of spatial OD models that represent an extension of the spatial regression models described in Anselin(1988).

INTRODUCTION

U-CITY(UBIQUITOUS CITY), the Korean smart city model, was made to take advantage of the developed Korea's Information technology(IT) infrastructure and to make urban management easier such as disaster prevention and crime prevention. U-City projects in Korea have been operated by government test-bed projects and are underway to build a nationwide (MOLIT, 2013). In particular among the projects, CCTV integrated management service to take care of crime-ridden districts getting responses from people. The most important reason for attracting attention to U-City is the concept of 'physical distance' is weakening. Because older cities are now changing into IT infrastructure basis management environment.

Housing sales price, a research subject of this study, can also be seen evolving change pattern with U-City system. Since housing fixes on the land, it has a unique feature that cannot move. Thus, house sales prices have not been determined independently and usually formed by exchange influences among the neighbored regions; it is widely accepted theory(Park and Ahn, 2005; Gillen et al., 2001). However, housing prices so that Park and Kim(2007) has pointed out, sometimes showing another correlation with it other than neighboring or physical distance. As a typical example on Seoul, house sales prices in the Gangnam-gu affects the Mokdong and Jamsil area nearly without delay. Look at this on the basis, in addition to the regional neighbor and distance, several other influential acts believed to form the house prices.

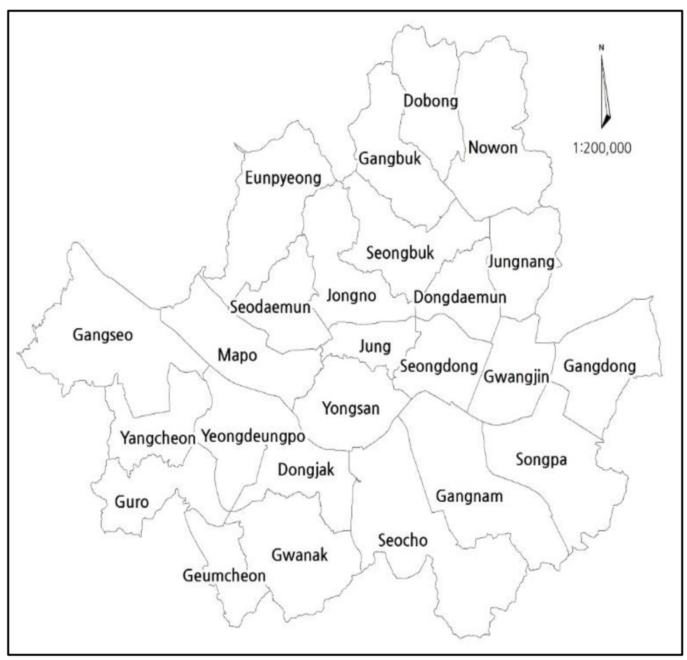

Figure 1. An outline map of the research area(Seoul, Korea)

*Corresponding author: Kabsung Kim
E-mail: kabsung@yonsei.ac.kr

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In this study, to recognize the fact that such changes in the U-City and another urban model is likely to affect home sales, new spatial weights matrix (SWM) that can reflect the influence would like to propose. In addition, we have been studying with an emphasis on understanding the statistical significance and efficiency of the new SWM.

THEORETICAL DISCUSSIONS AND PREVIOUS RESEARCHES

Studies in regards to real estate values have generally taken two theoretical flows. While one flow follows the equilibrium price model based on the law of demand and supply, another one centers around the hedonic price model by Lancaster (1966) and Rosen (1974).

The hedonic price model argues that the purchase of any good signifies the purchase of the entire good, including its inherent characteristics, and thus the price of a good is decided by its quantity and inherent characteristics. The hedonic price model is useful for a wide research subject as it can analyze the various elements affecting real estate prices. Within these logical boundaries, statistical methods such as regression models were applied to take into consideration the various characteristic of a house including generational, regional, and apartment-specific features. Of the various characteristics, the environmental element was studied in regards to unwanted public facilities such as trash incineration facilities (Cho, 1998) or detention centers and electricity substations (Choi et al, 2000) and their effects on the real estate prices. Preceding researches that studied real estate prices caused by social environmental
changes from public rental housings also applied these methods (Woo, 2005; Moon et al, 2006; Hwang, 2009).

Studies that follow the hedonic price model evolved alongside the development of improved statistical instruments. The most notable case is the use of hierarchical linear model. Hedonic price model fundamentally applies several variables of different levels including generational, regional, and apartment-specific features. Naturally, as it provides the most suitable tool for analyzing the variables, hierarchical lineal model has been frequently used in recent real estate price researches based on hedonic price model (Kim, 2003; Kim et al, 2004; Choi et al, 2004; Jung, 2006; Lee et al., 2012; Yoon et al., 2012). Another recurrently attempted tool is the spatial regression analysis, which can take spatial autocorrelation into consideration (Choi et al, 2003; Oh et al, 2014). These attempts are results of the due to the immobility of the real estate, which necessitates control over the real estate prices' spatial autocorrelation.

On the other side, about an SWM, there is also extensive literature. When it is first introduced by Anselin (1988), there are only a few generating methods utilizing adjacent or distance several generation methods exist. The simplest types of SWM are contiguity type matrices. However, over time, new generation methods have been developed. Getis and Aldstadt (2004) suggested over a dozen different types of SWM. Nowadays, the geo-statistical method is known as the most complex type. In between these differences are a host of different distance-related functions. Matters should focus on the debate on SWM is not a using complex or advanced method but specifying how research object is located in space concerning the other reference object. There are 3 types of considerations and viewpoints when making SWM (Aldstadt and Getis, 2006):

1. "A theoretical notion of spatial association, such as a distance decline function."
2. "A geometric indicator of spatial nearness, such as a representation of contiguous spatial units."
3. "Some descriptive expression of the spatial association within a set of data, such as an empirical variogram function."

In consideration of the above three perspectives on generating SWM, this study focuses on the third viewpoint. Because viewpoints 3 is more proper way than the others, perhaps. It can be proved in descriptive analysis and phenomenon-based researches.

PHENOMENON-BASED RESEARCH

Data Acquisition

The data used in this study can be divided mainly into two types. At first, the actual transaction data for calculating home sales was provided by「The Actual Acquisition Price of Real Estate Information System」which operates in MOLIT. In contrast to previous studies (Park and Kim, 2007; Lee and Park, 2013), the actual transaction data is used in the present study. Thus, it is expected to be a more sophisticated analysis can be done by reflecting the real price, not a call price. Data included three months from October to December 2015, and the total 19,131 sales data were collected. Data covered Seoul, Korea.

TABLE I

THE RESULT OF DESCRIPTIVE ANALYSIS

Variables			Measure	Mean	SD	Min.	Max
Dependent Variables (total 14 variables)	Physical Characteristics (total 10 variables)	Total Area	㎡	112.14	34.09	15.00	350.50
		Rebuilding is	Yes(%)	0.01	0.09	-	-
		Total Buildings		5.32	8.11	1.00	74.00
		Area for Exclusive Use	㎡	78.50	28.48	11.96	270.25
		Num. of Rooms		2.88	0.79	1.00	7.00
		Num. of Baths		1.52	0.57	1.00	3.00
		Total Household		412.82	548.98	45.00	5,540.00
		Parking Lot/HH		1.20	0.49	0.30	5.80
		Porch	Cascade	0.63	0.37	-	-
		Aging of Apts.	Years	12.38	9.18	0.00	36.00
	Environmental Characteristics (total 4 variables)	Dist. to General	Meters	1,732.15	812.33	133.86	4,552.27
		Dist. to Primary School	Meters	452.31	223.57	78.52	1,243.54
		Dist. to High School	Meters	720.94	391.08	52.22	3,005.38
		Dist. to Subway Station	Meters	635.30	262.41	42.29	2,802.51
		U-City Available	Yes(%)	44.00	0.13	-	-
Independent Variable		KRW/㎡	10thou. KRW	653.00	289.80	178.00	3,064.00

TABLE II

THE AVERAGE PRICES OF HOUSING SALES PRICES

Administrative Districts	Prices (in million KRW)
Gangnam	1010
Seocho	1004
Yongsan	832
Songpa	714
Mapo	627
Gwangjin	606
Jung	564
Seongdong	553
Jongno	551
Yangcheon	528
Dongjak	517
Gangdong	485
Yeongdeungpo	457
Seongbuk	418
Dongdaemun	404
Seodaemun	394
Gangseo	384
Eunpyeong	374
Gwanak	371
Gangbuk	348
Guro	344
Jungnang	315
Geumcheon	315
Nowon	297
Dobong	279

* Price : High to Low

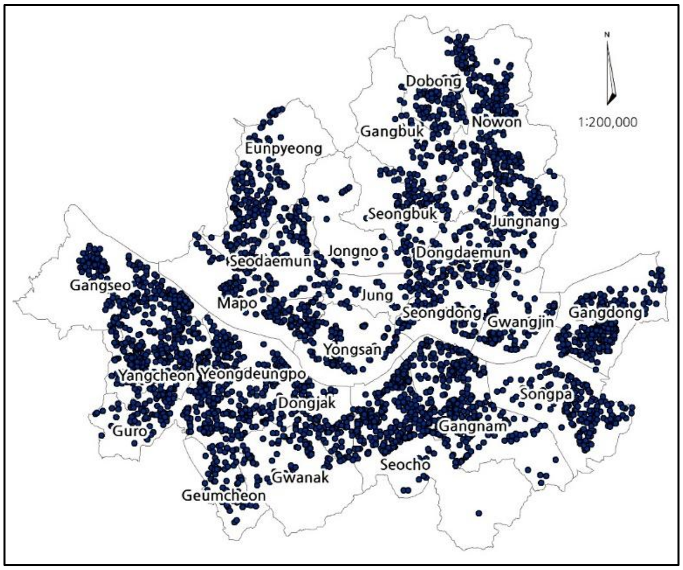

Figure 2. Apartment distribution map of the research area

Then, the building register to obtain the co-housing estates information was constructed in the database. This data was processed download from the large-capacity data providing system of "Architectural Information Open System", which operates in MOLIT. The building that has been registered as a "co-housing" in the construction in the December 2015 criteria Seoul, a total 96,603 buildings and this is a value except for the duplicates.

Next, it was processed and join in the parcel number unit (PNU) code for the purpose of trying to analyze together the actual acquisition price information and information of the co-residential complex to prepare for those mentioned above. Matching rate is 100%, all of the information has been fully joined.

Finally, to calculate the other environmental variables, get the (X, Y) coordinates of subway stations and bus stops from geographic information system (GIS) shape file. Make the GIS spatial operations utilization to analyze the traffic environment, the educational environment, and the living environment.

Basic statistics of data obtained through these process is as <Table 1> below. Which is a feature that was the rebuilding related variable is added that is not described in the previous variable explanation. According to the Park and Kim (2007), general buildings prices decline gradually over time because the life expectancy due is approaching, but the apartments prices are not when if reconstruction plan exists. Therefore, after the ‘reconstruction plan’ variable has inserted as a control value, then the analysis was performed.

Graphical Analysis

As a result of comparing the distinction apartment sale price, it has been derived as <Table 2>. Gangnam shows highest average sale price in Seoul, and then Seocho, Songpa, and Yongsan form high price group. Nowon has lowest mean sales price, and then Dobong, Geumcheon, and Eunpyeong join small price group. The average sale price difference between Dobong District(showed the lowest cost, 279 million KRW) and Gangnam-gu, showed the highest amount of money (1,010 million KRW) was found to be up to about 3.6 times.

After a visual analysis of time-series change over the study period, the graphs in the fourth quarter of 2015 showed that draws a steady graph does not cause noticeable changes. Therefore, it can be analyzed by the cross-sectional method to derive the mean quarterly without including the features of the time-series data. The distinct feature is that buying and selling price has a downward trend in the Gangseo (Magok district), which is expected to intensive housing supply in the future (about a year). For the reason of this trend appeared, Magok district has lots of long-term periods chonsei housing and public rental housing, so it has an adverse impact on the price in the vicinity of the apartment (Kim et al, 2015).

Correlation Test

It was carried out correlation test to explain the similarity of these distinctions sale price movement statistically. First of all, looking at the area that showed a high correlation, Seocho-Gangnam-Sangpa region, as we saw in the previous graphical situation analysis had been given a strong influence each other. This influence could be explained by the proximity of the group.

However, when seen in the reference to the Gangnam, it was found that has signed Yangcheon, Yeongdeungpo, a high correlation also Nowon. Despite the considerable distance away from each region, it seems to be having an unknown impact in determining the sale price fluctuations and some relationships between each sphere.

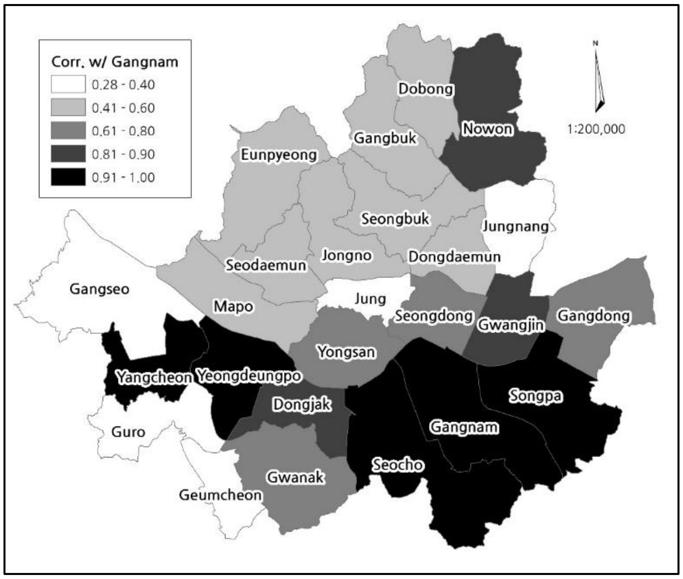

Figure 3. Correlation map with Gangnam and the others

The Yangcheon District that shows the distinctive look. Yangcheon, as seen in the following <Figure 4>, in addition to the Mapo and Yeongdeungpo, which are adjacent to each other and also appeared receive affecting both Gangnam and Seocho. This seems to be due to Mokdong Newtown is located in the Yangcheon. Mokdong is a large-scale apartment complex that has been construction in 1985-1988, and forms a high level of house prices in the Yangcheon as education fever is a very high. Because Gangnam•Seocho shares with this feature and is estimated that show such a correlation. That it might seem that the correlation and also due to some other influence, except for the fact that geographical proximity can see in the example Yangcheon.

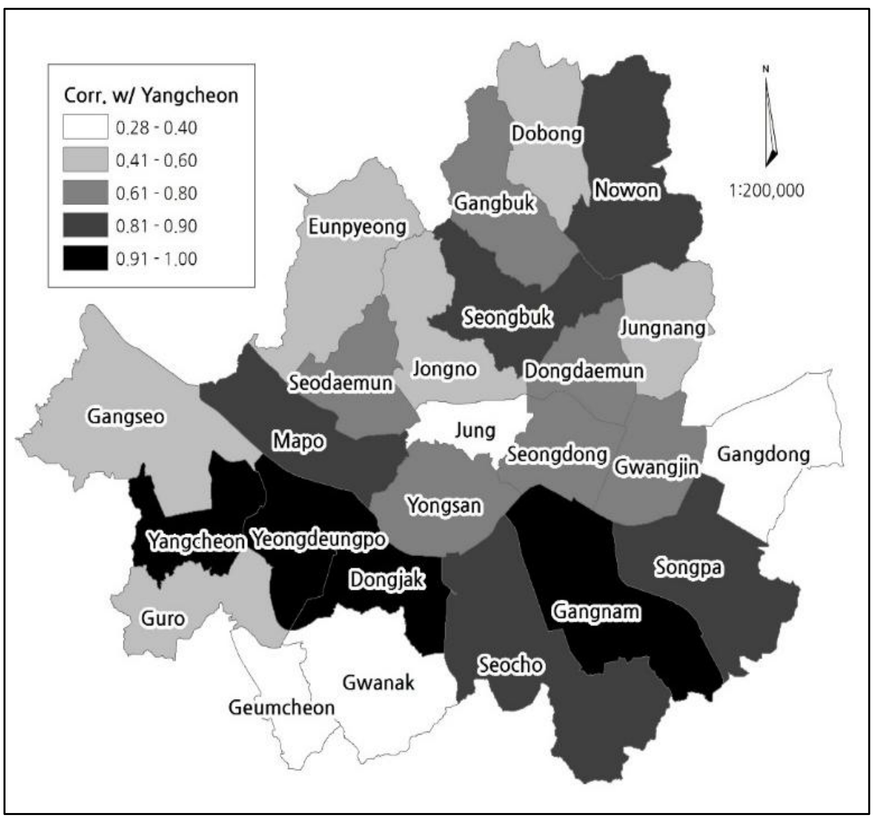

Figure 3. Correlation map with Yangcheon and the other

Full result of correlation test is as follows <table 3>.

TABLE III THE RESULT OF CORRELATION TEST

	GN	SC	YS	SP	MP	GJ	JU	SD	JO	YC	DJ	GD	YP	SB	DM	SM	GS	EP	GA	GB	GR	JN	GC	NW	DB
GN	1.00																								
SC	0.97	1.00																							
YS	0.66	0.71	1.00																						
SP	0.95	0.97	0.61	1.00																					
MP	0.56	0.59	0.93	0.55	1.00																				
GJ	0.81	0.77	0.61	0.78	0.42	1.00																			
JU	0.38	0.43	0.92	0.44	0.65	0.51	1.00																		
SD	0.72	0.68	0.42	0.65	0.48	0.66	0.38	1.00																	
JO	0.55	0.64	0.73	0.57	0.82	0.36	0.82	0.47	1.00																
YC	0.91	0.88	0.69	0.84	0.86	0.75	0.29	0.67	0.42	1.00															
DJ	0.86	0.91	0.87	0.81	0.77	0.78	0.29	0.65	0.49	0.91	1.00														
GD	0.66	0.65	0.31	0.64	0.51	0.33	0.28	0.45	0.24	0.37	0.39	1.00													
YP	0.91	0.89	0.73	0.86	0.89	0.71	0.54	0.70	0.45	0.94	0.86	0.35	1.00												
SB	0.58	0.61	0.55	0.55	0.42	0.64	0.73	0.66	0.70	0.81	0.53	0.48	0.67	1.00											
DM	0.43	0.39	0.64	0.40	0.43	0.71	0.89	0.63	0.81	0.72	0.60	0.77	0.82	0.97	1.00										
SM	0.53	0.54	0.76	0.58	0.88	0.69	0.80	0.56	0.79	0.77	0.54	0.69	0.83	0.61	0.87	1.00									
GS	0.30	0.33	0.45	0.33	0.66	0.57	0.41	0.20	0.33	0.56	0.49	0.54	0.69	0.45	0.49	0.41	1.00								
EP	0.41	0.48	0.60	0.49	0.42	0.22	0.69	0.40	0.78	0.51	0.45	0.41	0.59	0.59	0.66	0.79	0.71	1.00							
GA	0.61	0.62	0.78	0.57	0.37	0.40	0.51	0.66	0.33	0.28	0.71	0.63	0.65	0.45	0.42	0.60	0.77	0.80	1.00						
GB	0.59	0.64	0.59	0.68	0.63	0.70	0.66	0.59	0.61	0.69	0.78	0.42	0.63	0.93	0.82	0.69	0.51	0.68	0.44	1.00					
GR	0.34	0.37	0.62	0.41	0.55	0.44	0.58	0.72	0.40	0.55	0.51	0.59	0.43	0.34	0.33	0.64	0.78	0.55	0.88	0.26	1.00				
JN	0.39	0.36	0.25	0.22	0.21	0.57	0.46	0.80	0.59	0.41	0.33	0.48	0.50	0.66	0.86	0.23	0.39	0.77	0.51	0.69	0.38	1.00			
GC	0.28	0.23	0.55	0.42	0.54	0.48	0.43	0.51	0.37	0.35	0.45	0.38	0.51	0.81	0.73	0.56	0.70	0.81	0.89	0.39	0.88	0.69	1.00		
NW	0.88	0.80	0.62	0.86	0.59	0.80	0.29	0.77	0.48	0.80	0.85	0.49	0.81	0.88	0.85	0.58	0.66	0.71	0.45	0.93	0.40	0.74	0.31	1.00	
DB	0.58	0.56	0.41	0.51	0.37	0.61	0.51	0.86	0.68	0.55	0.48	0.34	0.42	0.70	0.59	0.31	0.25	0.76	0.43	0.69	0.54	0.88	0.52	0.64	1.00

* GN : Gangnam, SC : Seocho, YS : Yongsan, SP : Songpa, MP : Mapo, GJ : Gwangjin, JU : Jung, SD : Seongdong, JO : Jongno, YC : Yangcheon, DJ : Dongjak GD : Gangdong, YP : Yeongdeungpo, SB : Seongbuk, DM : Dongdaemun, SM : Seodaemun, GS : Gangseo,

EP : Eunpyeong, GA : Gwanak, GB : Gangbuk, GR : Guro, JN : Jungnang, GC : Geumcheon, NW : Nowon, DB : Dobong

ANALYSIS MODEL

Spatial Autocorrelation Test

To run the spatial regression analysis, the dependent variable must be analyzed or draw a spatial autocorrelation. According to the existing research results, home sales prices that are specified in the dependent variable in this study, it is common to show the spatial autocorrelation properties. To examine the data that are used in this study whether show the same nature abovementioned or not, analyze by drawing a map. As a result, it had been divided high price areas and low price areas as a <Figure 5>.

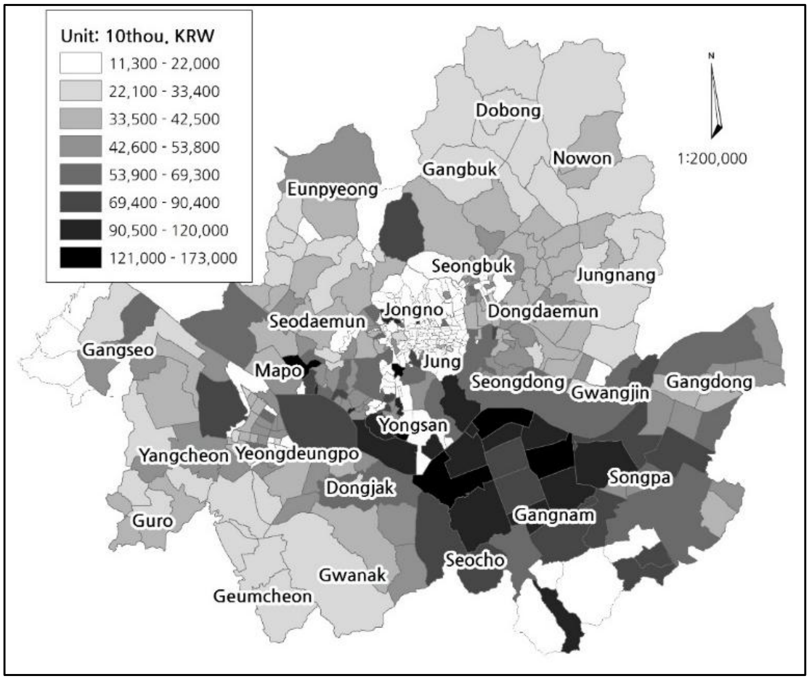

Figure 4. Apartment price map of the research area

Therefore, the research area's housing value, it is determined that there is a spatial dependency and would need more for the exact analysis through Moran's I coefficient statistical analysis(Moran, 1950). The research data was tested for globally spatial clusters through Moran's global clustering test to check whether spatial autocorrelation exists. Global Moran's I can be found through formula (1).

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{i,j} z_i z_j}{S\sum_{i=1}^{n} z_i^2}$$

$$where, S = \sum_{i=1}^{n}\sum_{j=i}^{n} w_{i,j} \qquad (1)$$

Here, z_i is the difference between the values of each feature and the mean $(x_i - \bar{X})$, while $w_{i,j}$ represents the spatial dependency between feature i and j. n Represents the number of all the features. The index I derived through this formula ranges from 0 to ±1 and the degree of spatially-correlation is stronger the closer the index is to ±1 and away from 0 (Li et al, 2007).

In this formula, X is a matrix of $(n \times k)$, Y is the $(n \times 1)$ vector and $W(u_i, v_i)$ is a matrix of $(n \times n)$. The diagonal elements in $W(u_i, v_i)$ represent the geographical weights of centric coordinate (u_i, v_i)'s region i and the adjacent n observing points. In GWR, W, the SWM, uses similar principles as the SWM used to calculate Global Moran's I and Getis Ord G Index, but is different as it is endogenously presumed.

Moran's I of the average sale price was calculated at 0.618 (Z-score is 9.11 SD). Thus, it was possible to grasp that the high level spatial dependence is shown.

Generating Spatial Weights Matrix(W_u)

Taken together the results of the phenomenon analysis, not only adjacency, but also other influences affect to the housing market in Seoul. Therefore, It is not rational that calculate distance only when generating the SWM for taking into account the spatial effects. The new expression configured to solve these problems, a <Formula 2> described below. From each nonnegative matrix $W = (w_{ij} : i, j = 1,2, \dots, n)$ is a possible SWM which summarizes spatial relationships among n spatial units.

$$W_d = (w_{i,j} : d_{ij}^{-2}) \qquad (2)$$

$$W_r = (w_{i,j}: \text{each element in} < Table\ 3 >)$$

$$W_u = W_d + W_r$$

Focus on the <Formula 2>, which is for composition matrix W_u, some variations were applied to the conventional method. First, obtain the original distance weighting matrix was names W_d. After that utilizing the correlation coefficient of <Table 3> to make housing price relational matrix. W_r is calculated from row standardization applied housing price relational matrix. W_u is finally derivate summing W_d and W_r, and conducted a row standardization again. Calculation formula of row standardization is <Formula 3>.

$$w_{i,j}^s = \frac{w_{i,j}}{\sum_j w_{i,j}} \quad (2)$$

Here, excluded self-explanation by assign that $w_{ii} = 0$ for all $i = 1,2,\dots,n$. So W has a zero diagonal element. Each element of the W_u is closer the distance between the apartment, and the higher the correlation of changes in the buying and selling price, with a greater value. The value of the case of the reverse is lowered.

Applying Spatial Lag Model

<Formula 4> is basically accept the existing spatial lag model utilizes W_u calculated in <Formula 2>. The reason for using spatial lag model is, in the study of Kim (2000), because it has been demonstrated that already a spatial lag model in the housing market of Seoul have explanatory power is superior to the spatial error model. Spatial lag model assumed that affected not only the explanatory variable of the internal housing prices in this area, but also the price of the house neighbored region(Anselin, 1988).

$$\mathrm{Y} = \rho W_u Y + X\beta + \epsilon$$

$$\begin{gathered} Where, \\ Y: dependent\ variables \\ X: independent\ variables \\ W_u: Unified\ SWM \\ \rho, \beta: parameters\ estimated \\ \epsilon: i.i.d. \end{gathered} \quad (4)$$

In this study, to adjust the ratio of the relative importance, from $(dist.importance : corr.importance = 0.2: 0.8)$and $corr.importance\ dist.importance = 0.2: 0.8)$ be subjected to analysis. At this time, the RMSE is to look for the best combination of high explanatory power as finding the smallest.

The statistics to refer to in order to determine what method is most effective in calculating the SWM is Akaike's Information Criterion (AICc), and it is generally agreed that SWM with minimal AICc is the best method (Fortheringham et al, 2002).

ANALYSIS RESULTS

Analysis, three models were performed, respectively. First is the OLS analysis commonly used, Second, SLM_d using distance based SWM (W_d), the third is a SLM_u using Unified SWM (W_u). The first model has been added to clarify that to derive the results of spatial regression was excellent much compared to the OLS. The second model and the third model, by comparing both, were analyzed separately in order to demonstrate the utility of W_u. Here, the weight of the correlation between the weights of the physical distance, respectively 0.4:0.6. This decision was reason in this way, will be described later.

Looking at the spatial regression analysis result of <Table 4>, SLM_u shows the highest R-squared value and lower standard error than the others (OLS, SLM_d). Since the Durbin-Watson numerical value has increased favorable direction, to 2, SLM_u is relatively free in multicollinearity problem. The spatial coefficient is in SLM_d displayed 0.384, in SLM_u is 0.327. It means that in SLM_u, correlation effect became independent.

AICc values and Maximum likelihood based measure (ML) represents the fit of the model SLM_u is more suitable than SLM_d. Conventionally ML is larger, AICc is smaller means that the model is appropriate.

As the individual variables point of view, whether the house's location belongs to the U-City or not because it did not meet the significance, it has been analyzed that does not have a significant effect on the housing prices of up to now.

Another special variable, there is a need to look at the variables age of the apartment. Because in OLS and SLM_d analyses demonstrated a positive sign, but in SLM_u analysis, it was shown a negative sign. Because the coefficient from SLM_u does not satisfy a significance level, so it is difficult to have a statistical significance. However, it can put a meaning to the calibration apartment variable in a common sense way while the process of building the SLM_u.

TABLE IV

THE RESULT OF SPATIAL REGRESSION ANALYSIS

Variables		Standardized Coeff.		
		OLS	SLM_d	SLM_u
Spatial Coefficient		-	0.384**	0.327**
Intercept		-51,928.2**	-62,151.4**	-57,837.3**
Physical Character.	Rebuild. is Scheduled	0.019**	0.022**	0.022**
	Total Buildings	0.107*	0.122*	0.123*
	Area for Excl. Use	0.799**	0.594*	0.587*
	Num. of Rooms	-0.044*	-0.026	-0.018
	Num. of Baths	0.007**	0.001**	0.002**
	Total Household	0.035**	0.029**	0.028*
	Parking Lot/HH	0.023*	0.028**	0.026*
	Porch	0.027**	0.024**	0.024**
	Aging of Apts.	0.094**	0.010*	-0.006
Environ. Character.	Dist. to General Hosp.	-0.026**	-0.029**	-0.029**
	Dist. to Pri. School	-0.010**	-0.015*	-0.014*
	Dist. to High School	-0.033**	-0.037*	-0.039*
	Dist. to Subway St.	-0.116**	-0.104**	-0.105**
	U-City Available	0.052	0.048	0.045
Diagnosis Values	Standard Error	20,589	17,047	15,680
	D-W	1.58	1.62	1.71
	R^2	0.72	0.74	0.78
	ML	-23,056	-19,159	-17,233
	AICc	39,593	36,101	34,816

**, *: .01 and .05 significance level, respectively

In this study, first, look at the correlation of the sales price for the entire apartment complex in Seoul, and it was examined whether can be explained only by the existing autoregression model. In the result of the analysis, apartment transaction price could have been formed not the specific phrase proximity only, but the some types of correlation between specific districts also. In the existing adjacency based SWM, it cannot reflect these correlations. Because there can be described the effect on the area outside the range of influence of the distance-decay function. To overcome these limitations, we proposed a new method for creating SWM.

Next, calculate the RMSE for each model to statistically compare the explanation power of the model. The result is 1.24 SLM_d and SLM_u is calculated as 0.95. So, SLM_d has a higher predictive power than SLM_u.

Like Abovementioned, the results of the spatial regression (<Table 4>) has stated that using specific ratio between physical distance and correlation coefficient. This is determined after going change the relative weights of the two forces that are

included in W_u compares the fit of the model.
The standard error of the <table 5> is smallest when $(dist.importance : corr.importance = 0.4: 0.6)$ and r-squared value is highest in the same condition. RMSE also represents a similar flow. So we decided respectively 0.4 and 0.6 is the best ratio after several tests.

TABLE V
THE RESULT OF SPATIAL REGRESSION ANALYSIS

Class		Goodness of Fit		
Physical Distance	Correlation Coefficient	Standard Error	R^2	RMSE
0.2	0.8	15,871	0.75	0.6
0.3	0.7	15,795	0.76	0.6
0.4	0.6	15,680	0.78	0.6
0.5	0.5	15,734	0.76	0.5
0.6	0.4	15,861	0.76	0.5
0.7	0.3	16,029	0.74	0.4
0.8	0.2	16,253	0.72	0.2

CONCLUSION

In this study, first, look at the correlation of the sales price for the entire apartment complex in Seoul, and it was examined whether can be explained only by the existing autoregression model. In the result of the analysis, apartment transaction price could have been formed not the specific phrase proximity only, but the some types of correlation between specific districts also. In the existing adjacency based SWM, it cannot reflect these correlations. Because there can be described the effect on the area outside the range of influence of the distance-decay function. To overcome these limitations, we proposed a new method for creating SWM.
As a result of spatial regression analysis utilizing the new SWM that reflects the price correlations, statistical significance was higher relatively as compared with the Ordinary Least Square (OLS) model. Further, it also had a smaller RMSE when using the modified SWM, so it is verified the analysis results are statistically valid. Thus, it is possible to conclude that real explanatory power of SWM considering the correlation of price fluctuations is stronger than existed simpler SWM such as calculated from distance or adjacency only.
In addition, the best experimental result was derived from various ratio attempt to change between physical distance significances and relatively correlation significances. Result ratio is 0.4:0.6, respectively. At those values, both fit and explanatory power were the highest. Conversely, that the changes caused by other price-related factors, such as Newtown construction or U-City construction have accounted for 60 percent, it can be said quite encouraging results.
However, it is limited in the fourth quarter of 2015 data used in this study can point out the limitations that are close to almost cross-section analysis. If it is possible to perform a future time series analysis, will be able to SWM proposed in this study receive a backing using a more robust model. Also, the analysis did not reveal the source of the correlational effect can be pointed out as well threshold. That is, another limitation of the analysis was only revealed only how much correlated its influence and there is missing detailed analysis.

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