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THE SPATIAL FACTORS AND RETAIL UNITS' PRICES IN SEOUL

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ABSTRACT

This study empirically tests the spatial factors of retail units' prices in Seoul. The spatial factors affecting retail units' prices can be classified into three main categories; market, site, and building characteristics. The first stage uses a multi-dimensional scale to investigate the three categories. The second stage uses the Regression Analysis with Ordinary Least Squares (OLS) to test the relationship between retail units' prices and various spatial factors. The data used in this paper includes property prices and retail units' characteristics of 315 properties in Seoul, Korea. Land price, size of the unit, and ground floor variables have been found to be positively correlated to retail units' prices. In addition, market, site and building characteristics (spatial factors) are also important determinants of retail units' prices. Size of the unit, unit entitlement, and ground floor also influenced retail units' prices in Seoul.

Keywords: retail unit price, spatial factors, multi-dimensional scale, Ordinary Least Squares (OLS)

1. INTRODUCTION

An understanding of the impact of spatial factors on retail unit price is of paramount interest to owners of and development to these properties. However, only limited empirical investigation into actual determinants of retail unit price is found. Although substantial research on value of retail property has been generated in the US and the UK to this date, there has been little empirical research on determinants of retail unit prices in Asia.

Retail unit price is determined locally and individually based on the retail trade area where target customers reside. Therefore, the economic power of the retail trade area significantly influences retail unit price in the district. Accordingly, any change in the economic power of the retail trade area leads to movements in rental price prompts new retail trade areas or shops to compete with the existing commercial establishment and brings changes in the consumers' standing. Changes in public transportation system, introduction of large wholesale or retail stores, establishment or relocation of public agencies or grand enterprises, and increase in income and accompanying change in consumption patterns, are some of the factors which may cause shifts of market power. Commencements of redevelopment and consumer taste diversification gave rise to intensive and complex usage of land in Seoul, thereby further strengthening the economic power of commercial trade area.

Despite the gravity of the economic power of retail trade area, researches on concrete factors influencing the economic power of retail trade area have been relatively neglected, thus far. Depending on the individual background of retail rent, predicting the operation and resale profits, and coming up with a strategy, have become important issues. Thus, this study will discuss variables that affect the retail unit prices and their importance by closely examining data on retail property in Seoul.

2. LITERATURE REVIEW

According to studies on rental price or retail real estate, stores located in a huge shopping mall are more competitive than stores located in a smaller shopping center (Eton and Lipsepy, 1982; Mulligan, 1983), and Ghosh (1986) described that landowners or low-level retailers benefit from the availability of multi-purpose shopping. Moreover, the lease term, percentage rent, or name value of franchise affect the rental value of each store (Benjamin, Boyle and Sirmans, 1990); and the size or age of shopping center or nature of anchor tenants may decide the rental price as well (Sirmans and Guidry, 1993). Also, stores which are traditionally known to draw a sizable volume of traffic often end up paying less for rent (The Center for Advanced Land Use Studies, 1975; Anderson, 1985). Many studies used the rental price of retail real estate and nature of the market or economic power of the primary retail trade area as an explanatory variable, but studies which deal with variables on the economic power of retail trade area are extremely limited. The buying power of retail trade area is known to be important in determining the amount of retail sales and setting rental price (Ingene and Lusch, 1980; Okoruwa *et al.*, 1994); and the image of anchor tenants or characteristics of the population are some of the variables that reflect the economic power of the retail trade area. (Hardin and Wolverton, 2001)

Retail unit price can be estimated by Huff's probability model. Huff's probability model has been used to estimate retail unit's performance. Size of shop, travelling time, and number of competitor

variables in Huff's model are all important factors. Retail units compete by capitalizing on site-specific drawing power. Huff's probability model states:

$$p_{ij} = \frac{S_j / T_{ij}^{\lambda}}{\sum_{j=1}^{n} S_j / T_{ij}^{\lambda}}, \qquad (1)$$

Where P_{ij} is the probability of consumer $_i$ retail unit $_j$, S_j is the size of a retail unit $_j$, T_{ij} is the travel time for consume$r$ j, n is number of competing retail locations and λ is the parameter reflecting effect of travel time on various types of shopping trips. This model presents a key departure from the earlier Central Place Theories (Christaller, 1966; Losch, 1954).

When S_j is replaced with $S_j MA_j LS_j BU_j$, the Huff's probability model can be restated as:

$$p_{ij} = \frac{S_j MA_j LS_j BU_j / T_{ij}^{\lambda}}{\sum_{j=1}^{n} \left[S_j MA_j LS_j BU_j / T_{ij}^{\lambda} \right]} \qquad (2)$$

MA_j is a vector of retail space market-condition variables for a given property, LS_j is a vector of site specific variables, BU_j is a vector of building specific variables including age and size of the retail unit.

Given the direct relationship a given retail unit's capture, each owner's expected economic profits and retail sale price, equitation (2) suggests the following empirically testable demand-side relationships:

$$S_j = f\left(\frac{\overset{[+]}{S_j}}{\sum_{j=1}^{n} S_j}, \overset{[-]}{MA_j}, \overset{[-]}{LS_j}, \overset{[+]}{BU_j} \right) \qquad (3)$$

3. MODEL

To empirically test the determinants of retail unit prices, the following model is used:

$$\mathbf{SP_{ji} = \mathit{f}(MA_j, LS_j, BU_j)} \qquad (4)$$

SP_{ji} is the sale price per square meter for retail unit. This section highlights areas of the existing literature in which spatial factors are considered as important determinants of sale price. The emphasis is placed on those market, site and building factors are described as key drivers of retail unit prices.

The Market

In general, market in retail property means a retail trade area or a spatial and local area and includes all the concepts that oversee the most practical place of trading for consumers as well as businesses. The retail trade area is usually evaluated based on the nature of the store, physical obstacles, competition within the market, driving distance…etc. According to the Central Place Theory, high-level goods and services industry's conditions influence tone of low-level goods and services market. That is, a high-level goods and services industry often affects the retail unit price for an area close to the industry. In addition, the special image of retail real estate or anchor tenants, or the economic power of retail trade area may increase the amount of sales in retail premises and the increase will be reflected in retail unit price.

The model also explains the recent accumulation of retail stores at centers of shopping districts and the crowding phenomenon which allows the consumers to visit many stores at once, thereby saving traveling costs. However, such phenomenon differs in scale and pattern depending on the local characteristics (Dipasqual and Wheaton; 1996). The accumulations of retail stores arise depending on the hierarchy or kind of retail products such as convenience goods or shopping goods (McDonald; 1999).

The structure or characteristic of retail trade area always changes. In general, the structure or characteristic of retail trade area is changing according to the physical conditions, such as type of residence, road construction and investment in new buildings. Factors describing the characteristics of retail trade area include the size, shape, local population, demographics (age, gender, income, and so on), potential expense, degree of market penetration, degree of market dominance, absorption power of client, access to store and transportation.

Factors determining the economic power of retail trade area include the price of real estate, population, housing industry and real estate development. The index describing the economic power of retail trade area include population, household, population density, population distribution, rate of increase in population, weekly population index, income and buying power for each product. The economic forces of such retail trade area differ depending on the type of real estate and it is using the index for the economic power of retail trade area for residence where the index includes the rate of home ownership, single housing, apartment, duplex housing and other types of housing.

Moreover, the economic power index of retail trade area related to industry includes the number of businesses, number of employees, spread of employees per industry, increase of sales amount in wholesale and retail businesses and degree of concentration within 1 km^2 for wholesale, retail, and restaurant businesses. The economic power index of retail trade area related to the real estate price includes monthly rent of store, deposit money for the rent of house and rental price of office. Lastly, the economic power index of commercial power related to real estate development includes the viability of the area to turn it into a commercial area adjacent to a subway station, commercial area through rezoning, part of land planning, business building, administrative town, residential and commercial building, project of expanding or repairing a road and redevelopment project.

Thus, based on the basic theory in the formation of a retail trade area, this study has considered the average retail sale price within the retail trade area, population of the retail trade area, the number or types of housing within the retail trade area and the number, types, or members of businesses within

the retail trade area to determine the retail sale price per ㎡. The average retail unit price of retail trade area according to this model is a function of effective buying power where the effective buying power is determined by the size of population and income within the retail trade area.

The Site

Location factors that affect retail property include five main variables: (1) access; (2) visibility, (3) traffics; (4) location within an urban area; and (5) the presence of other complementary stores, including restaurants. Access generally refers to the convenience of local transportation environment to the premise. Several empirical studies have linked accessibility to the location needs of retail stores. Visibility concerns the ability of potential customers to enjoy an unobstructed view of a store or its sign from a number of vantage points. The importance of visibility has been demonstrated with respect to retail location. Automobile traffics nearby the store are also an important consideration for store location. Readily access to banking, financial and real estate services may help rather than hinder sales. Availabilities of banking, financial and real estate services are referred to as business cluster.

The Building

With respect to the building, there are two major physical attributes: (1) site attributes consist of size, shape, topography, climate, vegetation, natural drainage, soil and subsoil; and (2) structure attributes include exterior physical features and interior physical features. Exterior physical features consist of substructure and superstructure. Interior physical features are composed of walls, supports and finish as well as equipment, mechanical systems, plumbing, heating, ventilating, and air-conditioning. In general, lower retail rent is charged on older shopping centers. Some studies underline detrimental effects of physical and functional obsolescence that arise as properties age. The age variable captures retail property depreciation and obsolescence thereby having negative impact to a statistically significant degree. The age of retail property is inversely related to the rent as older retail properties suffer from physical neglect, inappropriate tenant mix, and older facilities. Also, size of the property is the most dominant variable in the explanation of the property price. The shopping centre size variable is positive and statistically significant, indicative of a possible on site aggregation effect as centers increase in size.

4. DATA

The data set used for this study consists of data from 315 retail units in Seoul Metropolitan Area and the 2008-2009 Annual Statistics Report of Seoul. Retail unit price per square meter was assigned as a response variable, and retailer's market, site, and building were assigned as explanatory variables. The retail unit price per square meter in Seoul area came from retail properties, which were on the market from December 1st of 2010 to December 31st of the same year. The explanatory variables chosen were age of the property, parking space, passenger elevators, goods elevators, ground floor, lot size, size of a retail unit , land price, distance from CBD, the

width of the road, the street frontage, lot proportion fraction, total annual household income, expenditure per household, total deposits volume, and total loans. The data which were used in this study are transformed logarithmically and summarized in Table 1 below:

<Table1.> Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Sale Price (ten thousand won)	5,669.57	13,566.28	81.30	145,075.4
Age of the property(in years)	11.55	5.88	3	39
Parking space (㎡)	539.15	826.18	0	2184
Passenger elevators (each)	6.78	10.10	0	28
Goods elevators (each)	1.55	2.38	0	6
Ground floor (dummy)	0.19	0.33	0	1
Lot size (㎡)	4.85	64.68	0.01	1148.31
Size of a retail unit (㎡)	142.16	366.41	2	2304
Land price (won /㎡)	6,713,965	6,745,177	840,000	60,300,000
Distance from CBD(km)	10.43	3.58	0	21
The width of the road (m)	18.74	10.10	4	60
The street frontage (each)	18.74	10.102	4	60
Lot proportion fraction (㎡)	62.70	185.39	0.21	1680
Total annual household income (won / monthly)	4,570,094	1,677,984	5306	12,067,607
Expenditure per household(won / monthly)	3,529,021	1,048,313	3,530	6,709,590
Total deposits volume (Hundred million won/yearly)	161,457.6	788,179.4	4,126.82	4,481,541
Total loan(Hundred million won/yearly)	130,130.7	653,010.9	2,680.78	3,728,642

5. EMPIRICAL RESULTS

This study centered on the retail units in Seoul by utilizing the multiple-regression analysis. The research conducted: (1) correlation analysis of the variables; (2) identification of significant variables; (3) reduced model; (4) multi-dimensional scaling; and (5) structural equation modeling related to the market, site, and building.

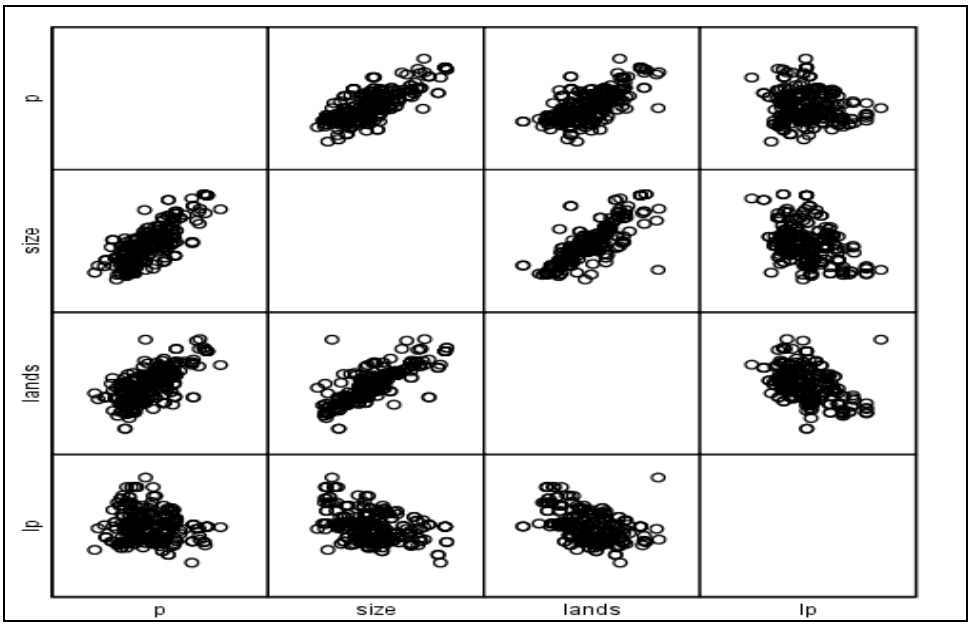
5.1. Analysis of Relationships between Variables

In order to establish the research model for this study, a bivariate scatter plot was analyzed to investigate whether retail unit prices had the standard distribution and to study the correlation coefficient between elements that determined retail unit prices. The resulting plot showed the elements that determined retail unit price in Seoul.

The spatial factors are considered important determinants of retail unit prices. In general, retail unit prices are positively related to size of the property. Figure 1 (below) shows the relationship between size of a retail unit and lot proportion fraction to be linear. If the two elements were to share an equal amount per unit in retail sale prices, they would spread out around the $y = x$ line. However, the data points of size of a retail unit and lot proportion fraction is located in the area where $y \geq x$, so one can see that size of a retail unit carries greater weight than the lot proportion fraction.

Moreover, the data points of land price and lot proportion fraction are located in the area where $y \leq x$, so one can see that land price carries greater weight than lot proportion fraction. Similarly, the data points of land price per ㎡ and size of a retail unit are located in the area where $y \leq x$, so one can see that the land price carries greater weight than the size of a retail unit. According to the scatter plot, there exists a linear relationship between the retail unit price per ㎡ and property size, lot proportion fraction and property size, or lot proportion fraction and land price per m^2, although some outliers were found. In particular, there is a clear linear relationship between size of a retail unit and lot proportion fraction.

<Figure 1.> Scatter plot matrix of response variables and major explanatory variables



Note: **P** - sale prices per sqm; **SIZE** - store size of a retail unit; **LANDS** - lot proportion fraction; **LP** - land price

Moreover, the bell-shaped retail unit price is normally distributed as one can observe that the data points are linearly distributed (Appendix II). The data becomes less dense near both ends of the normal probability curve, the lower points are located below the main trend and the higher points are located above the main trend line. Based on the analysis above, retail unit price in Seoul may be calculated by adding the land price, size of a retail unit and lot proportion fraction and one can discover the existence of a positive linear relationship between the elements.

5.2. Identification of Significant Variable

Before identifying significant variables, proper number of variables, which make up the scaled-down model was selected through the plot that represents Mallows' C_p and adjusted coefficient of determination ($adjR^2$). According to Mallows' C_p, a scaled-down model with more than 2 but less than 11 variables was preferred, while the adjusted coefficient of determination ($adjR^2$) standard chose selection of 11 variables (Appendixes III and IV).

The result from the stepwise regression method is summarized in Table 2 below.

<Table 2> Stepwise Regression Method

Step	Variables	Partial R-Square	R-Square	$C_{(P)}$	F_0	Sig.
1	*Size of a retail unit*	0.5925	0.5925	181.512	455.11	0.0001
2	*Land price*	0.0354	0.6279	140.765	29.65	0.001
3	*Ground floor*	0.0279	0.6557	109.079	25.18	0.0001
4	*Passenger elevators*	0.0317	0.6874	72.7972	31.41	0.0001
5	*Lot proportion fraction*	0.0304	0.7179	38.0048	33.34	0.0001
6	*Age of the property*	0.0151	0.7330	21.6995	17.47	0.0001
7	*The street frontage*	0.0061	0.7392	16.2723	7.23	0..0076
8	*Goods elevators*	0.0030	0.7421	14.6792	3.53	0.0613
9	*Distance from CBD*	0.0032	0.7454	12.7599	3.88	0.0496
10	*Expenditure per household*	0.0022	0.7476	12.0591	2.69	0.1019
11	*Total loans.*	0.0026	0.7502	10.9472	3.12	0.0782

5.3. Reduced Model

The result from analysing the final OLS (Ordinary Least Square) regression model using the stepwise regression method is summarized in Table 3 below. For the major variables, steps 1 and 2 selected size of a retail unit, land price as in the forward selection method, step 3 ground floor selected, step 4 passenger elevators, step 5 selected lot proportion fraction, step 6 selected age of the property, step 7 selected the street frontage, step 8 selected goods elevators, step 9 selected distance from CBD, and step 10 selected total annual household income, and step 11 selected total loans. Based on the past studies and stepwise selection of variable, this study was able to build the optimal regression model like Table 3. The stepwise selection of variable was appropriate for this scenario because the value of F_0 was higher than values obtained from other variable selection methods. However, one must be warned that none can assure the optimal regression equation, or there could be more than two equations.

When the statistic of 11 explanatory variables is investigated, *P*-values of all the variables except goods elevators, total annual household income, and total loans are below 0.05, thereby making them significant above 95% confidence level. In addition, the adjusted coefficient of determination ($adjR^2$) which denotes the explanatory power of the optimal regression model was 0.74, which was rather high when compared to the results from previous studies.

Based on the parameter estimate of regression coefficient, implies the following regression equation:

$$ln\_\hat{y} = 9.25 - 0.40*(ln\_AGE) + 0.16*(ln\_EPE) + 0.23*(ln\_ETH) + 0.67*(GF) + 0.66*(ln\_SIZE) + 0.48*(ln\_LP) + 0.16*(ln\_DCBD) - 0.27*(ln\_RN) + 0.25*(ln\_LANDS) - 0.14*(ln\_EX) - 0.09*(ln\_LOAN) + e \quad (5)$$

Where, AGE = age of the property; EPE = passenger elevators; ETH = goods elevators; GF = ground floor; SIZE = size of a retail unit; LP = land price; DCBD = distance from CBD; RN = the street frontage; LANDS = lot proportion fraction; EX = expenditure per household; LOAN = total loans

<Table 3> Analysis of Variance (a) and Parameter Estimates (b)

(a)

Source	DF	Sum of Mean	Squares Square	F Value	Pr > F
Model	12	419.55330	34.96277	76.12	<.0001
Error	302	138.71466	0.45932		
Corrected Total	314	558.26796			
	Root MSE	0.67773	R-Square	0.7515	
	Dependent Mean	16.76821	Adj R-Sq	0.7417	
	Coeff Var	4.04176			

(b)

Variable	DF	Parameter Estimate	Standard Error	t Value	Prob > |t|	Variance Inflation
Intercept	1	9.25295	1.40731	6.57	0.0001	0
Age of the property	1	-0.40360	0.08307	-4.86	0.0001	1.17075
Passenger elevators	1	0.16856	0.06390	2.64	0.0088	4.08607
Goods elevators	1	0.23467	0.09601	2.44	0.0151	3.37541
Ground floor	1	0.67668	0.10426	6.49	0.0001	1.14948
Size of a retail unit	1	0.66418	0.05289	12.56	0.0001	4.10685
Land price	1	0.48985	0.07583	6.46	0.0001	1.87081
Distance from CBD	1	0.16354	0.08569	1.91	0.0573	1.39187
The street frontage	1	-0.27033	0.08507	-3.18	0.0016	1.19297
Lot proportion fraction	1	0.25456	0.05099	4.99	0.0001	4.80496
Expenditure per household	1	-0.14385	0.05457	-2.64	0.0088	3.13965
Total loans	1	-0.09523	0.04786	-1.99	0.0475	2.87035

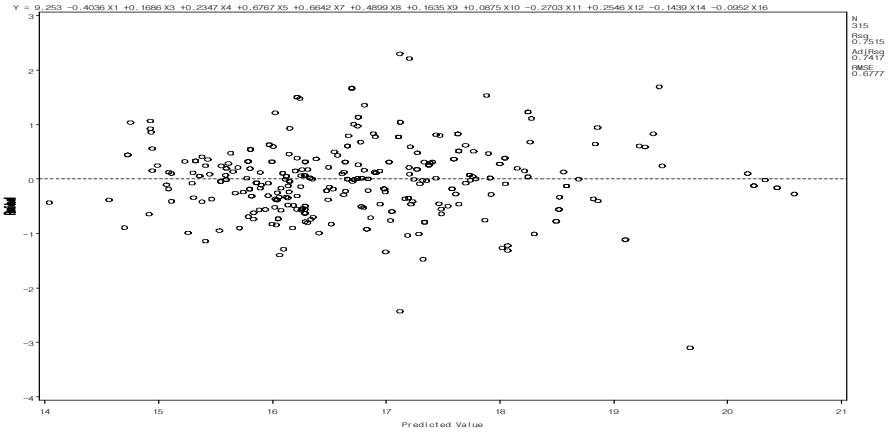
Next, this study investigated the relative importance of variables in explaining retail unit prices. Here, when the standard estimate was employed to find out the weight of each explanatory variable, the importance decreased among the variables in the following order; size of a retail unit (+12.56), ground floor (+6.49), land price (+6.46), lot proportion fraction (+4.99), age of the property (-4.86),

the street frontage (-3.18), passenger elevators (+2.64), expenditure per household (-2.64), goods elevators (+2.44), and total loans (-1.99).

To verify the appropriateness of the final model written in the Equation 5, this study investigated residual analysis, influence evaluation and multi-collinearity.

The independence of residue, homogeneity of variance, and normalization were investigated to review the appropriateness of the model using the chosen variables. The value of Durbin-Watson was obtained to discover the independent nature of residue. As the value of Durbin-Watson D is 1.615 (number of observation = 315, first order autocorrelation = 0.191), the independent nature of residue is also satisfied. In order to check the homogeneity of variable in residue, a residual plot was drawn in Figure 2 below.

<Figure 2> Residual Plot



The residual plot displayed a distribution shape concentrated in certain area, and this is a phenomenon often found in data representing the value of real estate. There does not appear to be any discernable pattern in the plot indicating that a straight line fit is appropriate. From the scatter plot of residuals against predicted values, we can see that there is no clear relationship between the residuals and the predicted values. In addition, this study employed the histogram and normal probability to investigate the normalization of residue, and the residue had a shape close to a normal distribution, thereby satisfying normalization (Appendix VI).

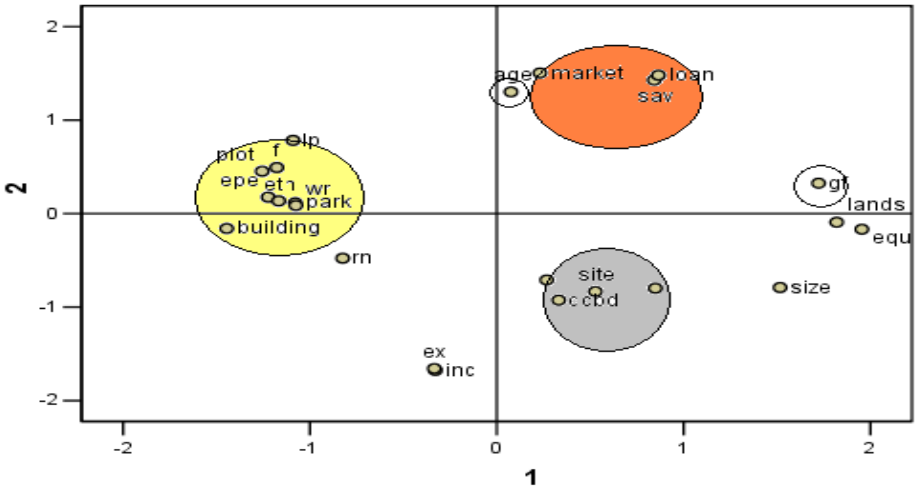
This study also analysed the multi-collinearity based on variable inflation factor (VIF). As the variable inflation factor for each selected variables was less than 7 the Table 3, multi-collinearity among individual variables of the regression equations was not a problem.

5.4. Multi-dimensional Scaling

The sixteen variables are plotted upon the positioning map with two axes, (1) land characteristics and (2) building characteristics in Figure 3 below. The individual variables are then mapped out next to each other and any gaps could be regarded as possible areas for new variables. It can be concluded that variables tend to bunch in the low land characteristics and high building

characteristics sector (Building Factor) and also in the high land characteristics and low building characteristics sector (Site Factor). There are variable in the high land characteristics and high building characteristics (Market Factor).

< Figure 3> Positioning Map



Note: Axis 1 = land characteristics: Axis 2 = building characteristics

5.5. Structural Equation Modeling

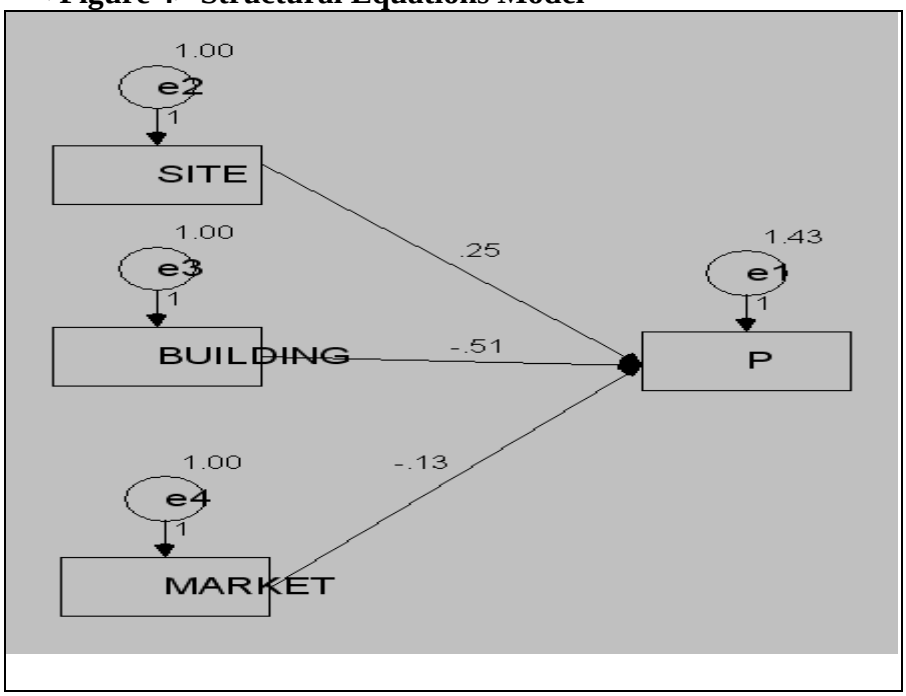
From the Equation 4, the retail unit price is regraded as function of the market specific variables, site specific ones, and building specific ones, From the Appendix IV Principal Component Analysis, the meaning of each factor can be interpreted based on the common characteristics of the results. It shows that the Factor 1 can be called the building factor, the Factor 2 can be called the market factor, and the Factor 3 can be called the site factor. The Factor 4 and 5 can be called the building 2 and building 3 factors respectively. The results of the factor regression are shown in the Table 4. The *Beta* (β) values indicate the relative influence of the variables. The building factor has the greatest influence on retail unit price (β = 0. 425), followed by the site factor (β = 0.157). The adjR^2 value indicates that about 42% of the variance in retail unit's price can be explained by the predictor variables.

<Table 4> Factor Regression

	Unstandardized Coefficients		standardized Coefficients	*t*	Signif of *t*
	B	Std.Error	Beta		
Intercept	16.768	0.057		294.204	0.000
Building Factor	-0.567	0.057	-0.425	-9.933	0.000
Market Factor	-0.08	0.057	-0.06	-1.402	0.162
Site Factor	0.21	0.057	0.157	3.674	0.000
Building 2 (loc) Factor	0.567	0.057	0.425	9.936	0.000
Building 3 (new) Factor	0.278	0.057	0.208	4.87	0.000

To illustrate multistage systems, assume that retail unit's price is influenced by the building, market, and site factors. The relationships among these factors are depicted in Figure 4 below.

< Figure 4> Structural Equations Model



In this diagram the connecting lines indicate relationships between variables, and the arrows indicate the direction of causality for those relationships. The 0.25 (site), -0.51 (building) and -0.13 (market) values are un-standardized regression coefficients that indicate the magnitude of each relationship. Thus, as in the earlier analysis, the function of retail unit prices within retail trade area is appropriate to have a retail unit prices decision model with variables representing the Market, Site, and Building factors.

In choosing the variables, the adjusted coefficient of determination (adjR^2) was the highest when the number of variables was 11, and the mean square error was the lowest. The figures showing the independence of residue, homogeneity of variance, and normalization were satisfactory when they were checked with the most appropriate model built by the chosen variables, and this study confirmed that the retail unit prices are affected by the Market, Site, and Building factors.

6. CONCLUSION

This study described in details how certain spatial factors affect the determination of retail unit price. For the empirical model, this study established a data set utilizing the retail units' price within Seoul and the Annual Statistical Report of Seoul. This study picked out significant variables among 16 variables related to the spatial factors using statistical analysis.

According to the analysis which determined factors affecting the retail unit price, *size of a retail unit, land price, and lot proportion fraction* were proportionally related to the retail unit price,

whereas *age of the property* were inversely related to the retail unit price. Especially, *land price* and *size of a retail unit* were found to be important explanatory variables in calculating the retail unit price.

When this study observed the statistic of the optimal model based on the 11 explanatory variables, each *P*-value for every explanatory variable except *distance from CBD* was found to be below 0.05, so the finding was significant with 95% confidence level. Also, both the adjusted coefficient of determination ($adjR_2$) at 0.74 and the value of *F* at 76.12 were rather high when compared to the results from previous studies.

The residual analysis, influence evaluation and multi-collinearity analysis were performed as parts of the regression analysis and the Durbin-Watson value of residue was found to be 1.615 thereby satisfying the independence of residue. Also, the distribution of residue was close to normal and the result satisfied the normalization.

Retail unit price is influenced by the spatial factor. The analysis shows that the spatial factors within the retail traded-area have highly affected retail unit price at the statistically significant level with the reliable model in Seoul.

This study makes original contributions to the literature by a retail unit price decision model with more detailed data such as the market, site, and building factors. Accordingly, this study through an empirical analysis has proved that the retail unit price in Seoul is affected by the market, site and building factors.

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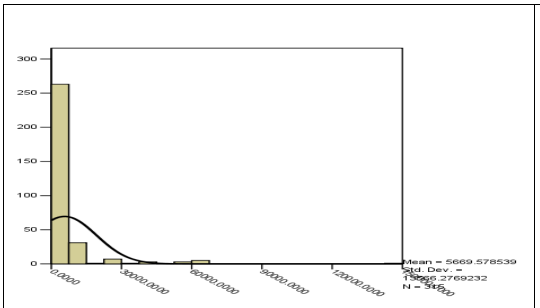
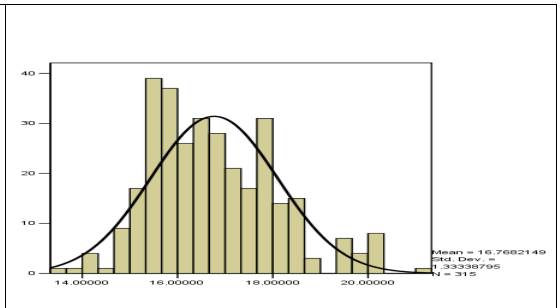
Appendix I: Define Variable

	Label	Define Variable	Unit	Type of Variable
Response variable	P(y)	Sale price	Ten thousand won / ㎡	Continuous data
Explanatory variable	AGE(x1)	Age of the property	In years	Continuous data
	PARK(x2)	Parking space	㎡	Continuous data
	EPE(x3)	Passenger elevators;	Each	Continuous data
	ETH(x4)	Goods elevators	Each	Continuous data
	GF(x5)	Ground floor	0 or 1	Dummy data
	PLOT(x6)	Lot size	㎡	Continuous data
	SIZE (x7)	Size of a retail unit	㎡	Continuous data
	LP(x8)	Land price	Won, ㎡	Continuous data
	DCBD(x9)	Distance from CBD	Km	Continuous data
	WR(x10)	The width of the road	m	Continuous data
	RN(x11)	The street frontage	Each	Continuous data
	LANDS(x12)	Lot proportion fraction	㎡	Continuous data
	INC(x13)	Total annual household income	Won / monthly	Continuous data
	EX(x14)	Expenditure per household	Won / monthly	Continuous data
	SAV(x15)	Total deposits volume	*Hundred million* Won / yearly	Continuous data
	LOAN(x16)	Total loans	*Hundred million* Won / yearly	Continuous data

Appendix II: Distribution of Variables

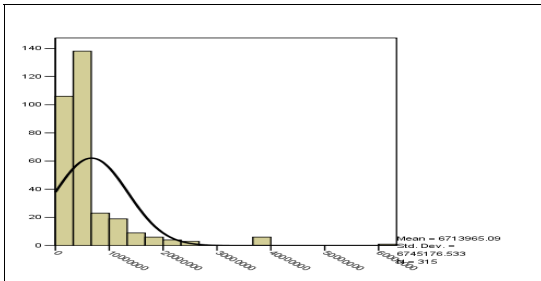


(a) Real Data



(b) Logged Real Data

1) Retail units' price



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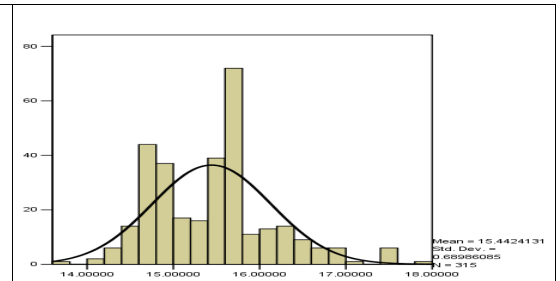
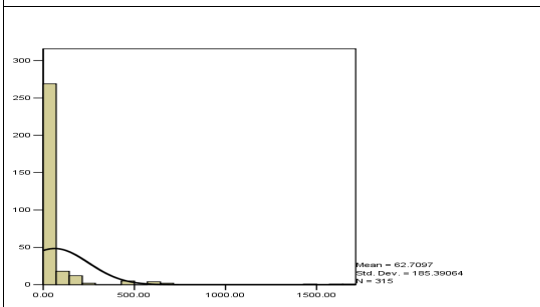
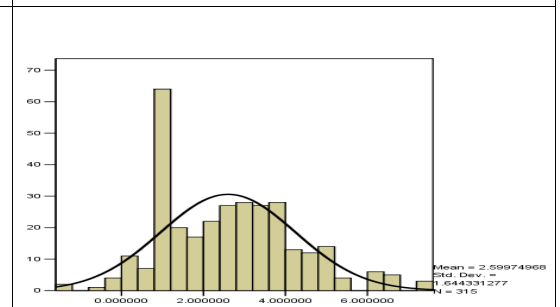


(b) Logged Real Data



(a) Real Data

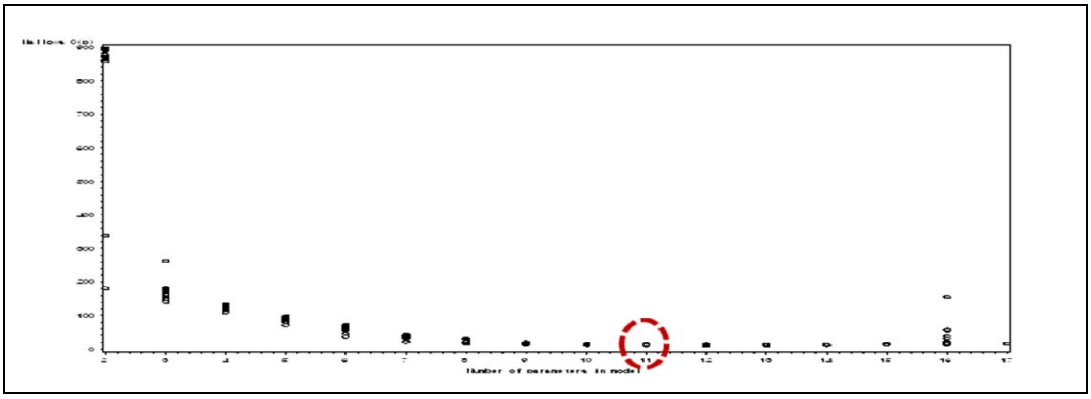


(b) Logged Real Data

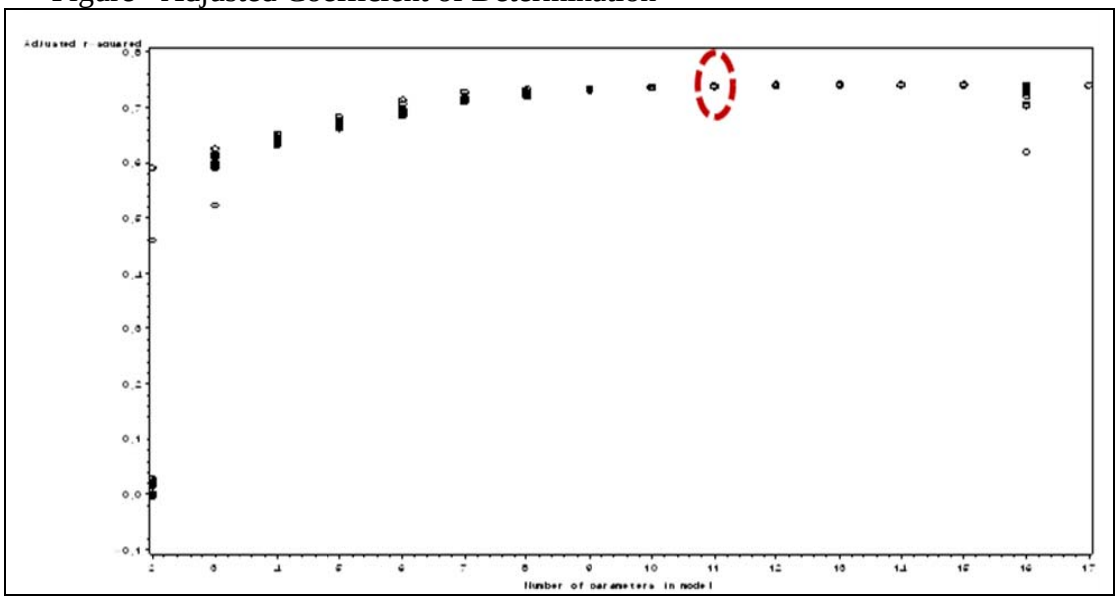
2) Land price (Up) and Lot proportion fraction (Down)

Appendix III: Mallows' C_p and Adjusted Coefficient of Determination ($adjR^2$)

<Figure> **Mallows' C_p**



<Figure> Adjusted Coefficient of Determination



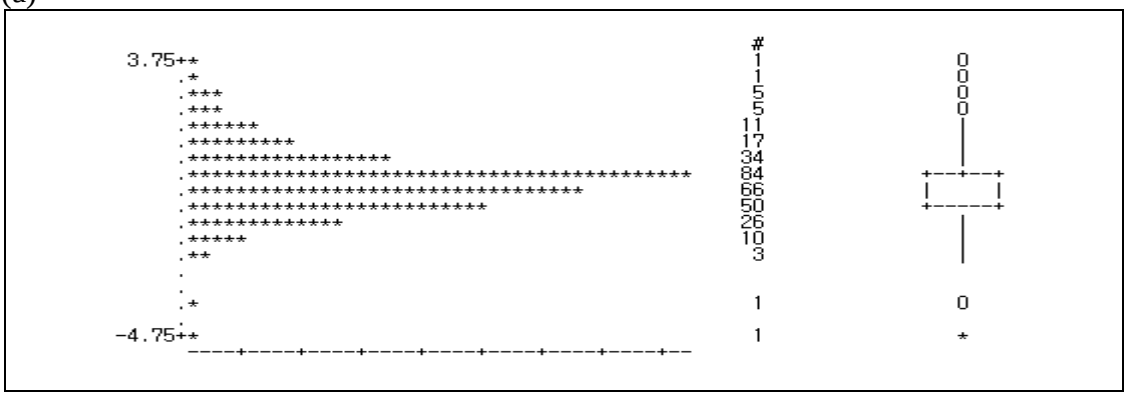
Appendix IV: Comparison of C_p, adjR^2, and MSE

VARIABLE	SIZE	SIZE LP	GF SIZE LP	EPE GF SIZE LP	EPE GF SIZE LP LANDS	AGE EPE GF SIZE LP LANDS	AGE EPE GF SIZE LP RN LANDS	AGE EPE ETH GF SIZE LP RN LANDS	AGE EPE ETH GF SIZE LP DCBD RN LANDS	AGE EPE ETH GF SIZE LP DCBD RN LANDS INC	AGE EPE ETH GF SIZE LP DCBD RN LANDS EX LOAN	AGE EPE ETH GF SIZE LP DCBD WR RN LANDS EX LOAN
P	1	2	3	4	5	6	7	8	9	10	11	12
C_p	181.51	140.76	109.07	72.79	38.00	21.69	16.27	14.67	12.75	12.05	10.65	11.31
Adj R^2	0.59	0.62	0.65	0.68	0.70	0.727	0.733	0.735	0.377	0.739	0.741	0.7417
MSE	0.85	0.81	0.78	0.75	0.71	0.69	0.688	0.685	0.682	0.680	0.678	0.6777

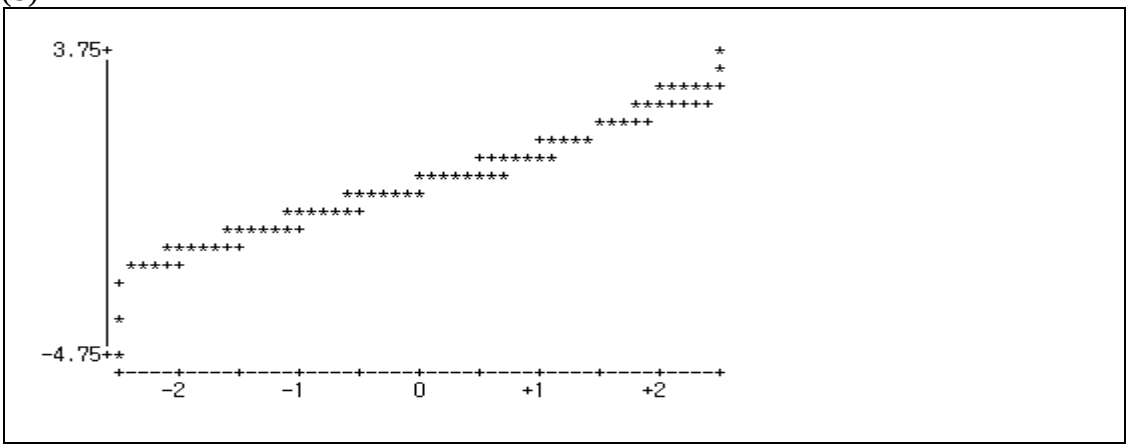
* **Note** : **AGE** - age of the property; **PARK** - parking space; **EPE**- passenger elevators; **ETH**- goods elevators,; **GF** - ground floor; **PLOT** - lot size; **SIZE**-size of a retail unit; **LP –** land price; **DCBD** - distance from CBD; **WR** - the width of the road; **RN** - the street frontage**; LANDS** - lot proportion fraction; **INC** - total annual household income; **EX** - expenditure per household; **SAV**- total deposits volume; **LOAN** - total loans.

Appendix V: Histogram (a) and Normal probability of Residue (b)

(a)



(b)



Appendix VI: Principal Component Analysis

Factor Matrix

	Factor				
	1	2	3	4	5
Age of the property	0.048781	0.124891	0.584648	-0.41754	0.464937
Parking space	**0.715827**	0.314571	0.072602	0.310312	-0.22222
Passenger elevators	**0.857657**	0.274019	0.137059	0.089068	-0.07997
Passenger elevators	**0.796607**	0.233021	0.224824	0.060501	-0.04013
Ground floor	-0.29893	-0.05253	-0.29876	-0.39924	-0.46623
Lot size	**0.565568**	0.148139	0.347615	-0.14921	0.334842
Size of a retail unit	**-0.57795**	-0.25217	0.418697	0.54021	0.021049
Land price	0.461773	0.093341	**-0.62707**	0.102664	0.313912
Distance from CBD	0.048588	0.019942	**0.617447**	-0.21384	-0.39273
The width of the road	0.552768	0.082029	-0.12601	0.359794	0.045455
The street frontage	0.406644	0.055252	0.170296	0.20963	-0.34576
Lot proportion fraction	**-0.74435**	-0.06829	0.293476	0.459751	0.109282
Total annual household income	0.234182	**-0.90431**	-0.09364	0.042423	0.084557
Expenditure per household	0.265067	**-0.90604**	-0.07208	0.048049	0.055329
Total deposits volume	-0.33942	**0.866322**	-0.10914	0.070664	0.059166
Total loan	-0.37676	**0.833077**	-0.16284	0.070876	0.061249