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The Estimation of Spatial Effects of the Office Rent in Seoul

서울 오피스 임대료시장의 공간적 영향력 분석

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목 차

I. Introduction

Commercial properties have been recognized as preferred assets due to their income-generating features. The value of a commercial property is influenced by various factors, such as the site individuality, the diversity of the use of the property, the kind of community that the property belongs to, and the neighborhood or environment surrounding the property.

These factors can also be said to have spatial effects on property. These spatial effects, particularly those pertaining to spatial dependence(spatial autocorrelation and spatial heterogeneity), have hardly been considered in general regression analyses.

Basu and Thibodeau(1998) argue that "House prices are spatially autocorrelated for two reasons. First, as several neighborhoods tend to be developed at the same time, neighborhood properties have similar structural characteristics, such as dwelling size and vintage. Second, neighborhood residential properties share location amenities with one another. For example, the same police and fire departments protect area residents." The first reason can be applied to office rent without any modification, and the second reason can be applied to office rent when location amenities are replaced with the income level of the community, the price of the property, or the rent level.

GIS must be applied if a hedonic price model with spatial autocorrelation would be used, and studies on quantitative space analysis are on the rise. A more sophisticated approach can be attempted by integrating GIS into a quantitative economic-space model and considering the spatial dependence. Such integration can make it easy and convenient to conduct space-weighting matrixing, spatial analysis, etc. As such, in this study, samples were extracted from three representative regions in Seoul(CBD, Gangnam, and Mapo/Yeouido), and the spatial effects on office rent were analyzed. This kind of spatial analysis for commercial property had not been done prior to this study, which makes this the first study on spatial autocorrelation in the Seoul office market.

This study is also expected to offer some insights regarding the correlation between rent level and spatial effects. If it is established that spatial effects play an important role in deciding the rent level in high-rent areas like CBD, then it can be concluded that rent level has a direct relationship with spatial effects. This conclusion can provide a quantitative ground for an adjustment rate related to rent level when appraising properties by comparing them with sales comparables. And the estimation using spatial autoregressive model can be utilized for more accurate calculation of office rents.

II. Literature Review

Most of the past studies on commercial property dealt with rent determinants. Sirmans and Guidy(1993) estimated the rent determinants for U.S. shopping centers. Using the empirical approach, they suggested that area and building age are the principal factors in determining the amount of rent in such commercial buildings. They made a remarkable contribution to the succeeding studies by pointing out the complexity of model framing and requiring additional researches on the matter.

Hardin Ⅲ and Wolverton(2000, 2001, 2002) examined the rent-deciding factors of community and regional shopping centers using an empirical approach. The factors that they examined included multipurpose shopping, purchasing power, and building image. Miller and Sklarz(1987) attempted a multiple-regression analysis of Hawaii condominiums using 607 property sale transactions between 1984 and 1985. Eppli(1998) also attempted a multiple-regression analysis of 54 regional shopping centers, focusing on the center size, parking ratio, center age, etc.

Until recently, we were hard to find related literatures because commercial property data are not available in Korea. Son and Kim(2000), Lee and Lee(2006), and Son and Yoon(2007) attempted a multiple-regression analysis of the rent in commercial properties in Seoul.

The mainstream of spatial-effect-related studies analyzes housing markets segmentation considering the location characteristics. In terms of methodology, there are studies to test errors of model specification, to estimate strength of spatial effects, and to test spatial heteroscedasticity.

Dubin(1988) estimated the hedonic parameters for Baltimore homes using 221 property sale transactions in 1978. Dubin assumed that the residual correlation between properties is a negative exponential function of the distance between them, and he estimated the hedonic parameters using the maximum likelihood procedure suggested by Mardia and Marshall(1984).

Can's(1990) specification included traditional structural characteristics and a neighborhood index computed through a principal-component analysis of nine census block group variables. Can(1992) examined the alternative spatial hedonic house price specifications for their heteroskedasticity. Basu and Thibodeau(1998) examined the spatial autocorrelation in the transaction prices of single-family properties in Dallas, Texas. They found strong evidence of spatial autocorrelation in transaction prices within regions, and there was evidence of spatial autocorrelation in the hedonic residuals for single-family properties located within a 1,200-meter radius. As they argue for these submarkets, appraisers need not concern

themselves with limiting their search for comparable properties to "proximate" transactions but must control only the differences in important structural characteristics.

Contemplating the fitness of model in prior literature, Kim(2000) came to the conclusion that SEM is more suitable estimating the spatial regression model in the household of Seoul including chonsei and owned houses, An(2005) utilized SAR model, and Hur(2007) decided SAC model is suitable in housing markets of both Busan and Seoul. In addition, statistical skills considering spatial statistics and spatial autocorrelation have been studied in detail by Dubin(1999).

An(2005) estimated the spatial effects on apartment prices. Using 202 observations of apartment prices in southern Seoul, he conducted a bootstrapping simulation of the spatial effects that measure the effects of a 1% variation in apartment prices in a region on the variation in other regions' apartment prices.

Park(2007) came up with a new weight matrix using the relativity number. Prior literatures, though, focused mainly on the housing market, and hardly any literature can be found on the commercial market.

III. **Modeling Framework**

Due to the economic importance of the estimation problem, both academics and practitioners have explored numerous statistical techniques designed to improve estimates.

Rosen's(1974) hedonic model(and those derived from it) admits multiple-regression functions. The hedonic equation for housing relates the market value of a property(usually measured by its sale price or rent) to the set of characteristics that determine the property's value. The general specification for a hedonic house price equation is given by

$$V = f(L, S, N, \cdots, t) \qquad < 1 >$$

where V is an estimate of the property's market value, L denotes those variables that describe the lot characteristics, S denotes the structural characteristics, N denotes the neighborhood variables, and t denotes the time period. In the standard linear-regression model, spatial autocorrelation can be incorporated in three distinct ways by using spatial weight matrices: as an additional regressor in the form of a spatially lagged dependent variable, or in the error structure or both(Anselin. 1988; LeSage. 1997).

First, the spatial error model(SEM) classifies an error term into a spatially autocorrelated error term, although it does not have to. The spatially autocorrelated error term is a controlled spatial information. A spatial error model is expressed as

$$y = X\beta + u$$
$$u = \gamma Wu + e \qquad < 2 >$$
$$e \quad N(0, \sigma^2 I_n)$$

where y is a cross-section variable, the matrix X is an independent variable, u is a spatially autocorrelated error term, is a spatial autocorrelation coefficient, W is a spatial weight matrix, and e is a random error term of homoscedasticity and non-autocorrelation.

Second, the spatial lagged model(SLM) is a lagged dependent-variable model that is similar to the time series regression model. In the model, the spatial lagged dependent variable has a spatial autocorrelation caused by the dependence of an independent variable. Thus, the spatial autocorrelation information is a set as an independent variable in the regression formula. ρ is a spatial autoregressive coefficient, and it denotes the degree of explanation by the space-weighting average of y-related variables.

$$y = \rho Wy + X\beta + \epsilon$$
$$e \sim N(0, \sigma^2 I_n) \qquad < 3 >$$

The last model is the combination of the above two spatial-regression models, and in another term, a combined spatial mode(SAC). In this model, one spatial weight matrix may be used or different spatial weight matrices may be applied. The spatial autocorrelation information of the dependent variable is set as an independent variable, and the spatial autocorrelation of the error term is controlled at the same time.

$$y = \rho\ W_1 y + X\beta + u$$
$$u = \gamma W_2 u + e \qquad < 4 >$$
$$e \sim N(0, \sigma^2 I_n)$$

This study attempted to use the above three autocorrelation models(SEM, SLM, and SAC) as well as the hedonic model(traditional OLS), to derive the most reasonable model, and to analyze the spatial effects. When the spatial weight matrix was coded, the distribution of weights was found to be inversely proportional to the square of the distance between office buildings and to have had a raw standard. This matrix, which was from the gravity model(the more distant an office building is, the less correlative its distance is to its price), was proven to be effective when it was used in the study of Kim(2000), Park(2004) and An(2005). In a general residential-market analysis, only the values within the critical range are used for the weights. In the office market analysis that was conducted in this study, though, the distance between the office buildings and the neighborhood buildings was also considered for the reasonable spatial weights.

Spatial-weight matrix was given the weight to be in inverse proportion to squared distance and standardized. This utilizes the gravity-model in which the farther the distance is, the weaker the interaction is. This

method was adopted by Kim(2000), Park(2004), An(2005), and Hur(2007) and revealed to be suitable. In general, as houses whose distance is farther than the critical point have no effects in housing market, these are excluded. In office market, it is also considered that buildings within the different sub-market are not affected by distance; therefore, the weight was not adapted.

$$w_{ij} = \frac{1}{d_{ij}^{a}}, \ a = 2 \qquad < 5 >$$

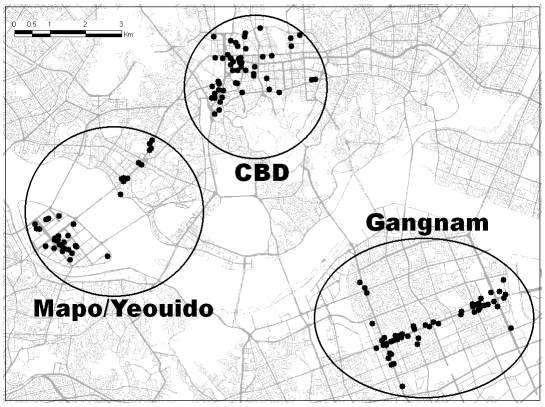
$$w_{ij=0} \text{ if } d_{ij} > D_c D_c = 1,2,3,4,5,\ldots$$

IV. Empirical results

1. Data

At the time of quarter of 2007, 50 buildings in CBD, 53 buildings in Gangnam, and 37 buildings in Mapo/Yeouido whose size was over the specific point in typical office market of Seoul were sampled. Even though a few skyscraper offices of prime level showed different rent, general offices determine their rent according to the third floor, which was chosen by the standard floor and rents were surveyed by it. The rent-payment of office is usually done by monthly rent with variable

Figure 1 _ Data Location



deposit in the market, but it was transferred to monthly rent without deposit in order to be able to compare the substantial rent.

The transfer rate was adopted to 5.75%, which was risk-less yield on corporate bonds(3 years) at July 2007.[1)]

This study adopted the basic variables that were used in the preceding office market studies,[2)] such as the market dummy variable(representing each trading area); the location variable, which includes the type of abutting roads, the distance from the nearest subway station, and the number of daily users of the nearest subway station(which indirectly reflects the demand for and size of the trading area) and the building variable, which includes age, area, parking spaces, number of

1) Lee and Lee(2005) suggest that it is probable there is no differentiation between ways of a contract -Cheonsei and monthly rent deposit- in a real market. According to the result, this study also performs analysis under the condition of not dualistic market, but the same one.

2) Son and Yoon(2007) included building age, remodeling, area, parking spaces, the number and width of the abutting roads, and the number of subway stations near a building among the market dummy variables they used in their study. Jeon and Lee(2006), on the other hand, included area, floor space index, building age, financing by an agency, distance from the nearest subway station, enterprise selling(dong), producer service density, and public service density for the same purpose.

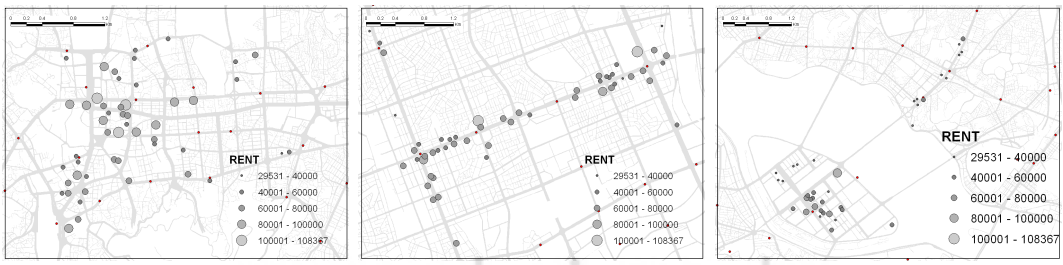
Table 1 _ The descriptive statistics

Variable		Frq.	Min	Max	Mean	Std. Dev
Rent(per 3.3㎡)	Total	140	29,531	108,367	60,319	17,863
	CBD	50	36,677	108,367	68,738	18,038
	Gangnam	53	29,531	106,688	61,764	14,712
	Mapo/Yeouido	37	31,381	94,313	46,522	12,624
Road	Arterial	101	–	–	–	–
	Path	24	–	–	–	–
	Alleys	15	–	–	–	–
Subway station	Distance	140	38	1,026	332	197
	Daily users	140	5,877	190,888	96,188	50,034
Building age		140	7	39	18	7
Story		140	9	60	18	7
Area	㎡	140	6,398	180,929	32,755	29,928
	3.3㎡	140	1,936	54,744	9,911	9,055
Parking spaces		140	0	1,437	220	204
Elevator number		140	1	36	6	6
Operating expenses(per 3.3㎡)		140	10,500	49,770	27,103	5,218

elevators, and operating expenses.

The total average rent was found to be 60,319Won/3.3㎡(68,738Won/3.3㎡, 62,312Won/3.3㎡, and 46,099Won/3.3㎡, respectively). The total average rent in the Mapo/Yeouido area was relatively low. From the spatial point of view, the office buildings in CBD are very close to one another, and they surround the City Hall. The Gangnam office buildings are largely extended into the two major roads(Teheran Road and Gangnam Taero). In the case of Mapo/Yeouido, these two areas can be considered one and the same district separated only by Han River, although they are physically far from each other. It was reported that the average distance between a building and a subway station in these representative regions is 332 m the average

Figure 2 _ Range of Rent



(1) CBD (2) Gangnam (3) Mapo/Yeouido

building age is 18 the average number of building stories is 18 the average gross floor area is 9,911 3.3㎡ the average parking space can accommodate 220 cars the average number of elevators is 6 and the average operating expenses are 27,103Won/3.3㎡.

2. Estimation Results

The road type, the number of daily users of the nearest subway station, the number of building stories, the number of parking spaces, and the number of elevators are independent variables, and the locational decision variables did not attain statistical significance even at the 10% level in the OLS model. In addition, even if a dummy variable were used, as in the preceding studies conducted by Son and Yoon(2007), it would not have attained statistical significance at the 5% level, and the unit variation of the coefficient would not have turned out to be great either. The gross floor area of the Mapo/Yeouido office buildings is large, and there are many new buildings in Gangnam.

Otherwise, it was found that there are many old buildings and not enough parking spaces at the center of the city, considering that it is a relatively-high -rent-level area. From this, it can be concluded that the chaotic and complicated characteristics of the office buildings in the representative regions made it hard to produce the effect of homogeneous direction.[3)]

Table 2 _OLS Model

Variable		OLS (Coefficient)
const		12.3376***
Region(dummy)	CBD	0.1673***
	Gangnam	0.0657
Road(dummy)	Arterial	0.0651
	Path	0.0702
Subway station	Distance	−0.0003***
	Daily users	0.0075*
Building age		−0.0035
Story		−0.0009
Area(3.3㎡)		0.0000
Parking spaces		0.0002
Elevator number		0.0059
Operating expenses(per 3.3㎡)		0.0000
Model Summary	R2	0.6984
	Adj. R2	0.6699

note: *** statistical significance less than 1%
** less than 5%
* less than 10%

The unit variation of the number of connecting roads(a kind of locational factor) is the biggest and the effects of the numbers in daily users of the nearest subway station ranked next. The elevator number mostly had effects on the characteristics of the individual building but the floor space and the operation expenses didn't have an effect on that. Therefore, for accuracy in coding the models, the analysis that was done in this study was

3) The representative methods of testing spatial dependence are the Moran's I test, the Lagrange Multiplier(LM) test, and Geary's coefficient test. Moreover, there are three general statistical modeling methods that are used to find out the appropriateness of MLE: the Wald test, the likelihood ratio(LR) test, and the LM test.

performed without considering these variables.

Based on the results of the spatial weight matrix, it was found that there were only slight differences between the variables in all the office buildings and the region office buildings in the neighborhood. As such, only the specified results of the spatial weight matrix, those that focus on the differences of the spatial effects in the neighborhood

market(in other words, not the total office but the local district office building in this study), were presented herein. Moran's I, LM Error, LR, Wald, and LM Lag were put into operation to verify the spatial dependence.[4)]

Moran's I has a normal distribution, and the others have a distribution of $x^2(1)$. In other words, Moran's I should be compared with the critical value(for the significance level from the standard normal distribution), and the others should be compared with the value of $x^2(1)$. If the value of Moran's I turns out to be bigger than that the critical value, the null hypothesis will be rejected.

Moran's I can be made statistically valid by rejecting the null hypothesis when it is 1%, which declares that spatial dependence exists. Moran's I will have a positive(+) value if the observed values are similar to one another; otherwise, it will have a negative(−) value. For the whole area of Seoul, the value of Moran's I was found to be 0.2912, a positive value, which means that spatial autocorrelation exists therein.

In addition, the most suitable model should be chosen by coding the actual model as LM(Error), LR, Wald, or LM Lag, and the statistics should be validated.

The SAC model has the highest log likelihood value(188.7260), but it(the coefficient represents the spatial effects) did not attain statistical significance at the 5% level. In the case of the SAR model, even if its attained statistical significance at the 5% level, the value of its log likelihood is the lowest. Thus, considering the statistical significance of the explanatory variables, it was determined that the most appropriate model to use is SEM.

As such, the spatial effects that were determined using the SEM model in this study were compared with those determined using the OLS model. The adj. pseudo R2 of OLS

Table 3 _ Test of Spatial Dependence

Variable	MI	Value	Prob	$x^2(1)$
Moran's I	0.2912	5.4534	0.0000	
LM(Error)		25.1113	0.0000	17.6110
LR		29.9773	0.0000	6.6350
Wald		127.0728	0.0000	6.6350
LM(Lag)		46.5323	0.0000	6.6350

4) In the study that was conducted on the Seoul commercial real−estate market(Lee and Lee. 2006), many individual −building variables did not attain statistical significance at the 5% level.

Table 4 _ OLS versus Spatial Models

Variable		OLS	SAR	SEM	SAC
		Coefficient	Coefficient	Coefficient	Coefficient
const.		12.4648***	8.1436***	12.4976***	11.5230***
Region	CBD dummy	0.2040***	0.0870*	0.2022***	0.1742*
	Gangnam dummy	0.1405***	0.0469	0.1387**	0.1169
distance between subway station		−0.0003***	−0.0002***	−0.0004***	−0.0003***
Building Age		−0.0039	−0.0033	−0.0026	−0.0026
Area		0.0000***	0.0000***	0.0000***	0.0000***
Operating expenses		0.0000***	0.0000***	0.0000***	0.0000***
Model Summary	ρ		0.3340***		0.0742
	ɣ			0.4660***	0.4050***
	R2	0.6839	0.6847	0.7345	0.7310
	Adj. R2	0.6697	0.6704	0.7226	0.7188
	Likelihood		106.9612	108.5267	188.7260
	DW	2.2080			

note: *** statistical significance less than 1%, **less than 5%, *less than 10%

was found to be 0.6697, and that of SEM 0.7226, which means that the spatial model improved much more in terms of statistics. However, in terms of the relation between the rent level and the variables, OLS and SEM had same−sign values, and the difference in their unit variation was not considerable.

Thus, there is a negative relationship between building age and distance. Otherwise, there is a positive relationship between gross floor area and operating expenses. This indicates that the results of this study coincide with the widely held idea that the older a building is and the farther it is from the metro, the lower the rent therein, and conversely, that the bigger a building is, the higher the rent therein. In the case of operating costs, however, buildings with higher operating costs or expenses are said to provide more services; as such, the rent therein is high. In the end, in deciding the rent level, that the buildings belong to, but the complicated, unique, the most important consideration is the community and locational characteristics of the buildings that were the subject of this study made it difficult to analyze this factor's steady influence on the rent level. Moreover, it is hard to recognize the effects of such factor on the rent level because the changes in the terms of the

contract are reflected not in real time but after the renewal of the contract, unlike with sales contracts.

V. Conclusions

This study analyzed the spatial effects on office rent in three representative regions in Seoul(CBD, Gangnam, and Mapo/Yeouido), and the spatial-regression model (controlling the spatial autocorrelation) was set up to produce the error of the hedonic price model that would disregard spatial dependence and spatial heterogeneity. The improved model showed no remarkable differences between the land market and the housing market in terms of spatial dependence. The results of this study show, however, that SEM is more suitable than the typical regression model(OLS) for office market analysis.

Moran's I coefficient(which can presume the spatial effects) represented the spatial dependence in this study. The strongest spatial dependence was observed in CBD, followed by Mapo/Yeouido and Gangnam(in this order). It was determined that the cause of this is the difference between the rent level and the spatial density rate. Contrary to what is widely believed, the individual-building variables(road type, number of daily users of the nearest subway station, number of building stories, number of parking spaces, number of elevators, etc.) and the locational variables did not attain statistical significance at the 5% level. These factors did not produce steady effects on the rent level and on the complex. The insufficiency of office buildings recently caused the vacancy rate to be under the frictional vacancy rate. As it is very hard to find out the market rent especially in the Korean office market, contract rent(the rent of the seller's market) was used for coding the SEM model. This is due to the fact that ρ, the coefficient which means spatial effects, is sufficient to the significant level statistically, although the value of log likelihood in SEM was lower than in SAC.

All these provided this model with some limitations as a tool for analyzing the effects of individual and locational characteristics on office rent. Moreover, the model could not be compared with the spatial effects of the region because this study used only grade A office buildings, which have limited variables.

As such, future analyses of the factors that influence the office rent level and the causes of the differences between office rent levels should include an investigation of the spatial effects of the individual real-estate market. Moreover, an analysis of the region effects and a time series analysis should be conducted to widen the study horizons. Notwithstanding its limitations, this study is unprecedented as an analysis of the spatial effects on office rent. Moreover, unlike preceding studies, this study used SEM, which is much better than the typical OLS model. It was found that CBD

has the strongest spatial effects because its office buildings are very close to one another and the rent level therein is high.

This study is to understand the effects caused by substantial externalities on space, but there is a limit to access available variables. Despite the drawback that the analysis is unable to control the effects of omitted-variables completely, it is meaningful that this paper shed light on being of the spatial effects in office market.

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ABSTRACT

The Estimation of Spatial Effects of the Office Rent in Seoul

Keywords: Rent, Office Market, Spatial Autoregressive Model, Spatial Autocorrelation

This study analyzed the spatial effects on office rent in three representative regions in Seoul (CBD, Gangnam, and Mapo/Yeouido) using three autocorrelation models (SEM, SLM, and SAC) as well as the hedonic model (traditional OLS).

The results of this study show that SEM is more suitable than the typical regression model (OLS) for office market analysis. Moran's I coefficient which can presume the spatial effects represented the spatial dependence. The strongest spatial dependence was observed in CBD, followed by Mapo/Yeouido and Gangnam. It is caused by the difference between the rent level and the spatial density rate. But this spatial effects of office market in Seoul were weak as compared with that of housing market because of supplier's market that the rent is decided by suppliers of office, so far.

Despite the drawback that the analysis is unable to control the effects of omitted-variables completely, it is a meaningful study dealing with the spatial effects of office market in Seoul.

서울 오피스 임대료시장의 공간적 영향력 검증

주제어: 임대료, 오피스시장, 공간자기회귀모형, 공간자기상관

본 연구는 서울의 대표적인 오피스 밀집지역인 CBD, 강남, 마포/여의도의 오피스빌딩을 대상으로 하여 임대료에 내재된 공간적 효과 및 영향력을 분석하고자 전통적인 OLS모형과 공간시차모형(SLM), 공간오차모형(SEM), 일반공간모형(SAC)을 사용하였다.

본 연구의 추정 결과 전통적인 회귀모형인 OLS보다 SEM 모형이 오피스 임대료시장에서 적합한 것으로 나타났다. 공간적 종속성을 추정할 수 있는 Moran'I는 CBD, Mapo/Yeouido, Gangnam의 순으로 강하게 나타났다. 이는 임대료 수준과 함께 공간적 입지 형태의 밀집도에 따른 차이에 기인한다. 그러나 추정된 모형 결과 개별건물의 특성요소와 입지변수가 10%에서도 통계적 유의성을 확보하지 못한 것은 변수들이 임대료에 일정한 방향의 영향력을 미치지 못하고 있는 것으로 판단된다. 본 연구의 경우 공간상의 실질적인 외부효과에 의한 영향을 파악하기 위한 시도였으나 주택시장과 달리 현재 오피스시장은 공실률로 볼 때 공급자 위주의 시장으로 임대료가 결정되고 있어 공간적 영향력은 비교적 크지 않은 것으로 분석되었다.

또한 현재 국내에서 확보 가능한 오피스 변수들이 제한적임에 따라 누락변수에 대한 영향력을 완전히 통제하지 못한 약점을 가지나 오피스시장에 있어 공간적 영향력을 확인한 것으로 그 의의가 있다.