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Analysis on the Spatial Dimension of the Commercial Domains: the Case of Seoul, Korea

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상업적 도메인의 공간 분석에 관한 연구
- 서울을 사례로 -

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Abstract : The innovation of information and communication technology has brought the emergence of the digital economy in which the growing importance of the Internet for the production and consumption of information has caused a rapid increase of commercial domains. Domains are basic form of Internet address for the delivery of information, but the location of registered commercial domains is not free from a spatial context. Utilizing a database of commercial domain registrations, spatial statistical methods and GIS, the spatial dimensions of the commercial domains are explored for the city of Seoul. Through this research, it was found that the commercial domains were unevenly distributed, namely 44% of commercial domains are located at 3 Gus in Seoul. The locations of commercial domains by themselves represented a strong spatial autocorrelation among adjacent places. In order to identify factors affecting spatial variation in the development of the commercial domains among Dongs, a conditional spatial autoregressive model which effectively eliminates a spatial autocorrelation was used. As a result of this research, it is clearly shown that the selective location of firms having commercial domains and their role in economic activities are influencing the spatial structure of urban with dynamic mix of spatial characteristic.

Key Words : the digital economy, commercial domains, spatial autocorrelation, a conditional spatial autoregressive model, spatial structure

요 약 : 정보통신기술의 급격한 혁신은 디지털 경제의 도래를 가져왔으며, 정보를 생산·소비하는데 있어서 인터넷의 중요성을 증대시켰을 뿐만 아니라 상업적 도메인의 급속한 증가를 가져왔다. 도메인이란 인터넷상에서 정보 전달을 위한 주소의 기능을 담당하지만, 실제로 등록된 도메인의 주소는 공간적 특성을 지니고 있다. 본 연구에서는 상업적 도메인의 공간적 분석을 위해 도메인 등록 원시자료를 데이터베이스로 구축하여 공간통계와 지리정보체계를 활용하였다. 서울의 경우 상업적 도메인의 분포는 44%가 단지 3개 구에 집중되어 있을 정도로 매우 불균등하게 나타나고 있으며, 상업적 도메인이 입지한 장소들 간에는 강한 공간적 자기상관을 보이고 있다. 본 연구에서는 상업적 도메인의 공간적 변이에 영향을 주는 요인들을 추출하기 위해 공간적 자기상관을 효율적으로 제거할 수 있는 공간자기회귀모델을 사용하였다. 본 연구 결과, 상업적 도메인 업체들의 선별적 입지와 이들의 경제활동은 동태적인 공간 특성을 보여주면서 도시내부의 공간구조 변화에 영향을 미치고 있다.

주요어 : 디지털 경제, 상업적 도메인, 공간적 자기상관, 공간자기회귀모델, 공간구조

1. Introduction

The innovation of information and communication technology(ICT) has brought the emergence of the digital economy spurred by a sharp decline of its price and a rapid diffusion of its application in socio-

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economic activities. The Internet is the most important element in the development and advance of the digital economy, linking remote places and peoples via the convergence of time and space (Dodge and Kitchin, 2001; Leinbach and Brunn, 2001). The Internet users of the world are estimated to be increased rapidly from 0.9 million in 1993 to 0.6 billion in 2002 (Chen and Wellman, 2003).

The Internet is a network linked through a global network of computers, which is hierarchically structured with various layers of value chains such as hardware, software, network providers and the Internet applications (Kogut, 2003). A rapid increase in the application of the Internet has created new ways of communication among people, of provision in public service, and of marketing in business, rapidly increasing new industries related to the production and consumption of information and knowledge (Gillespie, et al., 2001; Gorman and Malecki, 2002; Greenstein, 2002; Leinbach, 2001; Zook, 2003).

The Internet is an integrated system for the exchange of information and knowledge, for the mediation of shared interests, and for the production of new ways of business in terms of marketing, production and delivery (Moss and Townsend, 2000; Pelletiere and Rodrigo, 2001). Thus, the Internet emerges as a vital element for the development of dematerialized and digitalized economy. The growing importance of Internet for the production and consumption of information has caused a rapid increase of Internet domains. Domains are basic form of Internet address for the delivery of information via the networks of computers. Especially, commercial domains have increased rapidly and show the basic map of the development in the Internet activities (Sternberg and Krymalowski, 2002).

Commercial domains do not have a form of spatial entity, but their addresses of registration represent the spatial entity of firms which are vital actors in socio-spatial economy. Thus, the location of commercial domain registration renders an understanding of the spatial patterns of Internet activities in the exchange, production, and consumption of information and knowledge. The rapid development of Internet renders the rhetoric of the death of distance and geography, as the Internet links remote places into cyberspace, diminishing role for geography in economic and social activities (Cairncross, 1997). However, the commercial domains have developed mainly in large cities increasing the role of the urbanization economy (Zook, 2000).

The development of the urban economy such as labor pool, transportation and communication infrastructure, human capital and externalities is a fundamental factor for the location of commercial domains. Thus, the growth of commercial domains depends highly upon the agglomeration and the social, cultural and economic intensity of the urban economy for the acquisition of technology, knowledge, and information which have created, developed, and reconstructed as a historical and social processes, and formed as spatial fixity (Graham and Marvin, 2001; Leamer and Storper, 2001; Malecki, 2002; Warf, 2001; Wheeler, et al., 2000).

The concentration of the Internet activities has brought about the interest of spatial dimensions of the Internet (Gorman, 1998; O'Kelly and Grubesic, 2002), but there has been neglect on a spatial analysis of Internet presence and activity at different geographical dimensions such as national, regional, and local levels (Grubesic, 2002). Even though, analyses on the spatial patterns of domains have been conducted(Lee, 2002), research interest on the spatial analysis of commercial domains at the level of local has been neglected in Korea.

The purpose of this research is to explain the spatial dimensions of commercial domains, especially focusing on the spatial analysis of registered numbers of commercial domains in Seoul. This research attempts to examine the factors affecting the clustering of commercial domains in the metropolis of Seoul, utilizing spatial statistics which measures on the presence of spatial autocorrelation.

Process for this study is as follows; the next sec-

tion examines data and methodology for the spatial analysis of registered numbers of commercial domains. The third section explains the spatial patterns of commercial domains at the regional(*Gu*) and local(*Dong*) levels in the city of Seoul. The fourth section analyzes the factors affecting the development of commercial domains using spatial statistics at the level of *Dongs* in Seoul. The fifth section is for the influence of commercial domains in the changes of urban structure, followed by the concluding part.

2. Data and Methodology

1) Data

This research uses commercial domains for a spatial analysis of Internet activity in Korea. The registration address for commercial domains indicates the location of Internet content production (Zook, 2000). Thus, commercial domains are very useful data to measure the spatiality of the Internet. However, domain measurement has some distinct limitations (Dodge and Shiode, 2000; Grubesic, 2002; Moss and Townsend, 2000). First, domain does not consider the amount of flows of information or the size of firms. So, the amount of information flow through the domain of a large firm is regarded as the same of that of a small firm, making difficulty in the recognition of the characteristics of firms. Second, the location of domain registrations does not always correspond to the actual geographical location of firms. Third, firms are increasingly attempting to register multiple commercial domains in terms of different products and strategies in-house functions. Often, one IP address includes multi-information of domains.

However, an analysis of commercial domain registration is a useful way to understand the social and economic activities related to the Internet based production and application (Moss and Townsend, 2000). Especially, commercial domain registration represents the entity of corporate, which surrogates spatial patterns on the adoption and application of the Internet for the production and consumption of information (Grubesic, 2002; Sternberg and Krymalowski, 2002).

The Korean Network Information Center (KRNIC) controls the registration of domains(.kr) in Korea. Second level domain names are divided by the characteristic of organization, namely academic(.ac), company(.co), government (.go), research institute(.re), network(.ne), including regional domains(.seoul) and personal domains(.pe). At the end of 2003, 611,548 domains were registered in Korea, and commercial domains were 464,552 comprising 76% of domains. Data on the numbers of commercial domains are offered only by 16 administrative level in Korea. So, this research utilizes unpublished data set of commercial domains registered by Korea Network Information Center (KRNIC) at the end of 2002.

2) Methodology

Registered numbers of commercial domains were 440,498 in Korea and 283,103 in Seoul at the end of 2002. Spatial analyses are carried out at the level of 522 *Dongs* which are the smallest administrative boundary within Seoul. Measures of spatial autocorrelation on commercial domains will be used to explore the trend of clustering among 522 *Dongs* in Seoul. Indices of spatial autocorrelation represent the degree of interdependence in the values of commercial domains among *Dongs*, especially between geographically proximate *Dongs*. Moran's I and Geary's C are the most frequently used measures to detect spatial autocorrelation (Cliff and Ord, 1973; Lee and Wong, 2001) and Moran's I is defined as follows;

$$I = \frac{n\sum_{i}^{n}\sum_{j}^{n}\omega_{ij}(y_i-\bar{y})(y_j-\bar{y})}{(\sum_{i}^{n}\sum_{j}^{n}\omega_{ij})\sum_{i}^{n}(y_i-\bar{y})^2}$$

Where y is the variable of commercial domains transformed by log in polygons i and j (*Dongs*), $\bar{y}$ is the mean of y, and w_{ij} is a spatial weight matrix with values of 0 or 1. The value of 1 represents *Dongs* share a border, while 0 represents that *Dongs* are not

contiguous.

Moran's I values of +1 indicate a strong spatial autocorrelation, with high values located nearby and low values located nearby (Moran, 1948). Values near -1 indicate a strong negative correlation, with high values located near low values. Geary's ratio uses similar notation with Moran's I index, but uses σ^2 which is the variance of the attribute x values. Geary's ratio is defined as follows;

$$C = \frac{\sum_i^n \sum_j^n \omega_{ij} (x_i - x_j)^2}{2 \sum_i^n \sum_j^n \omega_{ij} \sigma^2}$$

However, global Moran's I and Geary's ratio do not reveal specific clusters of commercial domains, so this research uses local Moran's I to identify clusters of commercial domains at the level of *Dongs* in Seoul. Local Moran's I is defined as follows;

$$I_i = z_i \sum_j \omega_{ij} z_j$$

Where, $z_i = (x_i - \bar{x})/\delta$, and δ is a standard variation of x_i.

The regression model is used to explain what factors are driving the variation of the development of commercial domains in 522 *Dongs* of Seoul. However, basic ordinary least squares regression does not indicate spatial correlation, spatial dependence and spatial heterogeneity (Anselin, 2002; Griffith and Layne, 1999). Thus, ordinary least squares measure often results in mis-specification and irrelevant statistical inference. If there exists spatial autocorrelation, standard error estimator tends to being underestimated, and variance and correlation coefficients tend to being biased (Griffith, 1996). To remedy biased residuals of the ordinary least squares model, this study utilizes a conditional spatial autoregressive model (CAR). This offers better account for spatial bias incorporating a spatial lag into parameters, so the autocorrelation of residual values of ordinary least squares model can be effectively eliminated. Conditional spatial autoregressive model is defined as follows;

$$Y = \rho WY + X\beta + \varepsilon$$

Where, Y indicates a dependent variable, X independent variable, W spatial weight matrix, ρ and β estimated parameters, and ε indicates error term.

The regression model estimates the influence of variables for the development of commercial domains, but a regression model does not indicate the specialization of the development of commercial domains in each *Dong*. So, this study also uses location quotients to examine the specialization of commercial domains in each *Dong*. LQ is defined as follows;

$$LQ = (Xr_i / Xr)/(X_i / X)$$

Where, X indicates the numbers of all industry establishments in Seoul, and X_i the numbers of commercial domains in Seoul, while Xr indicates the numbers of all industry establishments in r *Dong* and Xr_i the numbers of commercial domains in r *Dong*.

For spatial analysis, all the registered addresses of commercial domains in Seoul were geocoded and *Dong* based domain registration data was placed in a dBase file. This table was exported to ArcView. S-Plus SpatialStats and S-Plus for ArcView GIS were utilized to measure spatial autocorrelation and conditional spatial autoregression(CAR) for this study.

3. Spatial Patterns of Commercial Domains

1) Spatial Pattern at National Level

An increasing digitalization of the economy has strongly influenced the growth of numbers of registration for commercial domains in Korea. In 1996, the registered numbers of commercial domains were only 2,069, but increased to 454,597 in 2000 (Figure. 1). However, this skyrocketing increase was not sustained in 2001 when ICT based venture enterprises experienced severe market competition, suffering by a decline of venture capital because of devaluating

of stock price in the IT sectors. Since 2002, the registered numbers of commercial domains increased again moderately. Domain registration has been mainly carried out by commercial usage, for example 90.8% of domains were commercial. However, the share of commercial domains in 2003 declined to 76% because of an increase of other domain name, for example personal domain name which comprises about 6%.

The number of registered commercial domains has been clearly concentrated to Seoul(Table 1). In 1996, 79.6% of commercial domains were located in Seoul, since then its share has been declined to 65.3% in 2002. The dominance of Seoul has been quite clearly sustained. But, the share of commercial domain in Busan, the second largest city, was only 4.1% in 2002. This share is quite low compared to its population size(3.7 million in 2000). The other 5 metropolises are also low in their share in the numbers of commercial domain.

One of remarkable spatial pattern of commercial domains is the role of the Gyeonggi province as an important location for the production of information. Gyeonggi, located surrounding area of Seoul with 9 million of population in 2000, comprises 12.0% of registered commercial domains. Thus, Gyeonggi has emerged as the second important region in the production and application of information in Korea. This importance of Gyeonggi in information related activities might be closely related to its proximity to Seoul. Since 1980s, this region has absorbed the influx of population from Seoul and other parts of Korea, resulting the development of new cities and industries, especially high technology based industries.

The other 8 provincial regions are not important location for the development of commercial domains. Thus, the spatial patterns of registered commercial domains are quite highly concentrated to Seoul and moderately to the Gyeonggi province. So, the Capital Region, which includes Seoul and Incheon metropolises and the Gyeonggi province, shows a strong centralization in commercial domain at 80.1% in 2002.

2) Spatial Patterns at Intra-metropolitan Level

(1) Spatial pattern at *Gu*-level of Seoul

The number of registered commercial domains

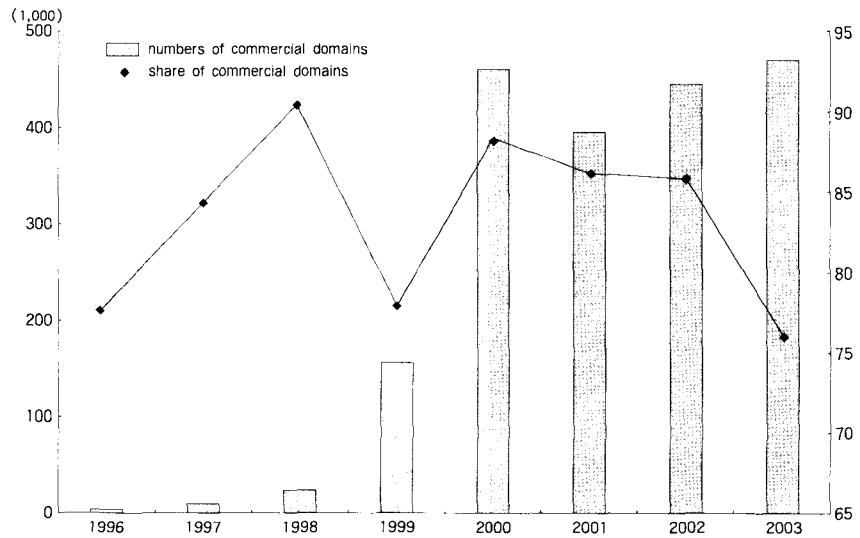

Figure 1. The numbers and share of commercial domains in Korea

Table 1. The share of the number of commercial domains in the 16 administrative regions

	1996	1999	2002
Seoul	79.6	59.7	65.3
Busan	2.5	4.7	4.1
Daegu	1.8	3.9	3.2
Incheon	1.0	3.0	2.8
Gwangju	0.8	2.0	1.9
Daejeon	1.0	2.1	2.0
Ulsan	0.4	0.7	0.7
Gyeonggi-*do*	8.8	15.0	12.0
Gangwon-*do*	0.9	0.8	0.8
Chungcheongbuk-*do*	0.4	0.9	1.0
Chungcheongnam-*do*	0.3	1.0	0.9
Jeollabuk-*do*	0.4	1.0	0.9
Jeollanam-*do*	0.1	0.8	0.7
Gyeongsangbuk-*do*	0.8	2.0	1.5
Gyeongsangnam-*do*	1.3	1.9	1.7
Jeju-*do*	0.0	0.6	0.4

Source: KRNIC, each year, unpublished data on the registration of commercial domains.

has been unevenly distributed at 25 Gus of Seoul. Commercial domains have been highly developed in several areas such as Gangnam, Seocho, Yongsan, Yeongdeungpo, Mapo, and Jongno Gus since 1998. In 2002, 44% of commercial domains are located at 3 Gus such as Gangnam, Seocho, and Yeongdeungpo. Gangnam-*Gu* and Seocho-*Gu* have been highly represented in LQs, namely 4.3 and 3.1 in 1998, 3.5 and 2.6 in 2002 in each(Figure 2). Both Gus were rapidly developed since the 1980s, initially developed as new residential areas since 1970s, but grown also for the business districts, now have became a leading place for the knowledge based services and IT related services (Lee, 2003; Shin and Jeong, 2002). Even though, Gangnam and Seocho's domination in location quotients have lessened slightly between 1998 and 2002, but their LQs are still very high, indicating their leading role for the production and consumption of information in Seoul.

However, the CBD area, contained by the administrative boundary of Jongno-*Gu* and Jung-*Gu*, has not been the most important place for the development of commercial domains in Seoul. The CBD area has been the most important place for the location of head offices of large firms, but, since the late 1980s, the CBD has confronted a severe competition from other business districts, especially business centers located in Gangnam-*Gu*, Seocho-*Gu* and Youngduengpo-*Gu*. Yongsan-*Gu* are relatively highly represented in LQs of commercial domains both in 1998 and 2002, outweighing the CBD area.

(2) Spatial pattern at *Dong*-level of Seoul

Registered commercial domains are highly con-

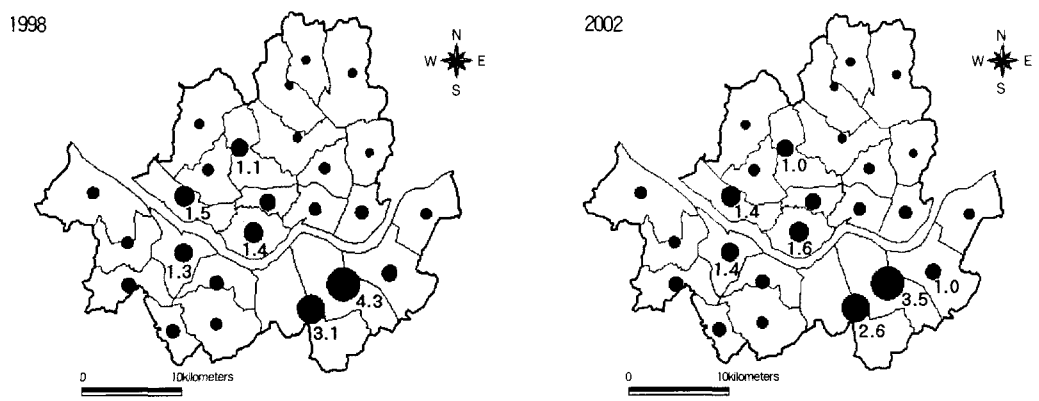

Figure 2. LQs of Commercial Domains at 25 *Gu*-level

centrated to the major business districts in Seoul at the end of 2002. Figure 3 shows the spatial patterns of registered numbers of commercial domains by geocoded dot map. Each commercial domain was geocoded by the geographical address of registered establishment, thus geocoded data are duplicated in the case that a building contains several domain-registered firms. The registered numbers of commercial domains by *Dongs* are represented in figure 4. Yeoksam1-*Dong* is a leading place with 14,082 domains, followed by Yeouido-*Dong*(9,407), Yeoksam2-*Dong*(7,374), Jongno1234-*Dong*(6,908) and Sinsa-*Dong*(6,443). Yeoksam1-*Dong* shares 5.7% of total commercial domains of Seoul, followed by Yeouido-*Dong*(3.8%), Yeoksam2-*Dong*(3.0%), Jongno1234-*Dong*(2.8%) and Sinsa-*Dong*(2.6%) (Table 2).

The most important spatial phenomenon is the development of domains in Gangnam-*Gu* and Seocho-*Gu*, generally termed as the Gangnam area. The Gangnam area comprises 36.9% of commercial domains. Fourteen *Dongs* from the top 20 *Dongs* in the number of commercial domains are located in Gangnam (9 *Dongs* from Gangnam-*Gu* and 5 *Dongs* from Seocho-*Gu*). Thus, these 14 *Dongs* take a leading role in the development of production and consumption for Internet related activities in Seoul.

The CBD area, namely Jongno-*Gu* and Jung-*Gu*, includes only 3 *Dongs* in the top 20, rendering Gangnam the most important place for the Internet related activities. The other three *Dongs* are Yeouido-*Dong* in Yeongdeungpo-*Gu*, and Hangangno2-*Dong* and Hangangno3-*Dong* in Yongsan-*Gu*. Thus, all the top 20 *Dongs* are located in the major business districts or their adjacent places (in case of Hangangno2-*Dong* and Hangangno3-*Dong*). The rest parts of Seoul does not include any *Dongs* in the top 20, but Seogyo-*Dong*(Mapo-*Gu*), Guro5-*Dong*(Guro-*Gu*), Ogeum-*Dong*(Songpa-*Gu*) and Guui(Gwangjin-*Gu*) have relatively high share in commercial domains.

Location Quotients also show similar spatial pattern for commercial domains in Seoul (Table 2)[2]. However, the dominance of Gangnam is more highly represented than commercial domain numbers. Eighteen *Dongs* from the top 20 are from this area, namely 13 *Dongs* from Gangnam-*Gu* and 5 *Dongs*

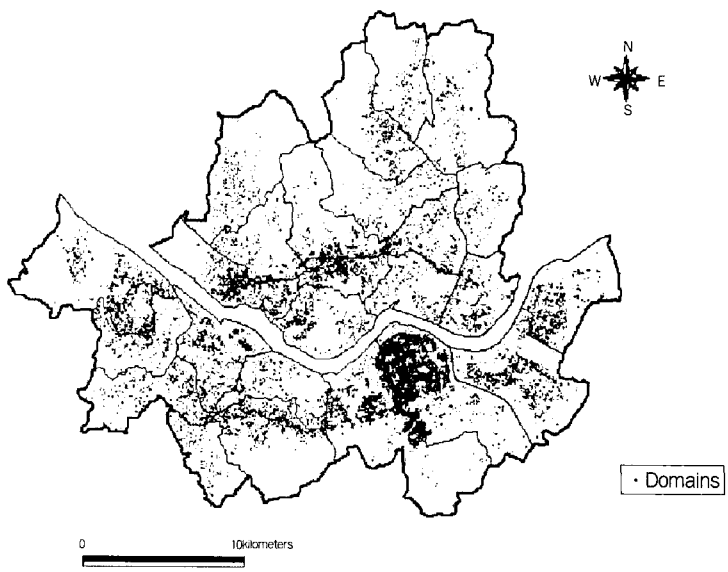

Figure 3. The distribution of commercial domains by geocoded dot map in Seoul[1]

Table 2. The top 20 *Dongs* for the number and LQ of commercial domains in Seoul, 2002

Top 20	Commercial Domain		Location Quotient	
	Dong	Share(%)	*Dong*	Value
1	Yeoksam1	5.7	Yeoksam2	8.9
2	Yeouido	3.8	Seocho2	6.3
3	Yeoksam2	3.0	Daechi3	5.7
4	Jongno1234	2.8	Sinsa	5.5
5	Sinsa	2.6	Dogok2	5.3
6	Nonhyeon2	2.3	Samseong2	4.9
7	Seocho3	2.1	Seocho4	4.3
8	Seocho2	2.0	Samseong1	4.3
9	Samseong1	1.9	Yeoksam1	4.1
10	Yangjae2	1.8	Nonhyeon2	4.1
11	Samseong2	1.7	Daechi4	4.1
12	Nonhyeon1	1.7	Yeouido	4.0
13	Daechi3	1.5	Dogok1	3.8
14	Hangangno3	1.4	Hangangno3	3.8
15	Daechi4	1.3	Jamwon	3.3
16	Euljiro345	1.3	Nonhyeon1	3.2
17	Seocho4	1.2	Yangjae2	3.2
18	Seocho1	1.2	Seocho1	3.1
19	Sogong	1.2	Cheongdam2	2.9
20	Hangangno2	1.1	Bangbae3	2.8

Source: KRNIC, 2002, unpublished data on registered domains in Korea.

from Seocho-*Gu*. LQs are especially highly represented in Yeoksam2-*Dong*(8.9), Seocho2-*Dong*(6.3), Daechi3-*Dong*(5.7), Sinsa-*Dong*(5.5), and Dogok2-*Dong*(5.3). Outside the Gangnam area, Yeouido-*Dong*(4.0) and Hangangno3-*Dong*(3.8) are pertained in the top 20. Therefore, the Internet related activities are highly specialized and concentrated within Seoul.

Spatial patterns from the registered numbers and LQs of commercial domains clearly show a concentration toward several *Dongs* of the major business districts in Seoul, especially Gangnam. This area thus emerges as a leading place for the development of information intensive activities. Further, the highly concentrated pattern of commercial domains around such area implies the possibility on spatial autocorrelation among *Dongs* of Seoul.

4. Spatial Context of Commercial Domains

1) Spatial Autocorrelation on the Distribution of Commercial Domains

Another tool for exploring the trend in spatial pattern of commercial domain is the measurement of spatial autocorrelation. The measure of spatial autocorrelation help to understand the interdependence of values in commercial domains at 522 *Dongs* of Seoul. The result of applying the global Moran's *I* measure for commercial domains in Seoul yields a value of 0.4903, which shows the presence of spatially autocorrelated observations. Also, Geary's *C* ratio yields 0.7618, representing a high level of similar characteristics occurred among adjacent *Dongs*.

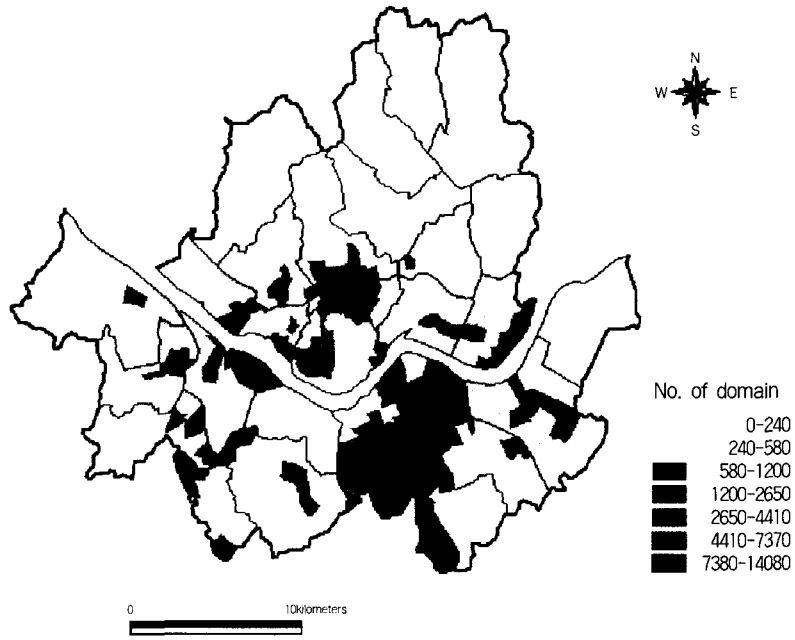

Figure 4. The spatial patterns of commercial domains at *Dong* level in Seoul

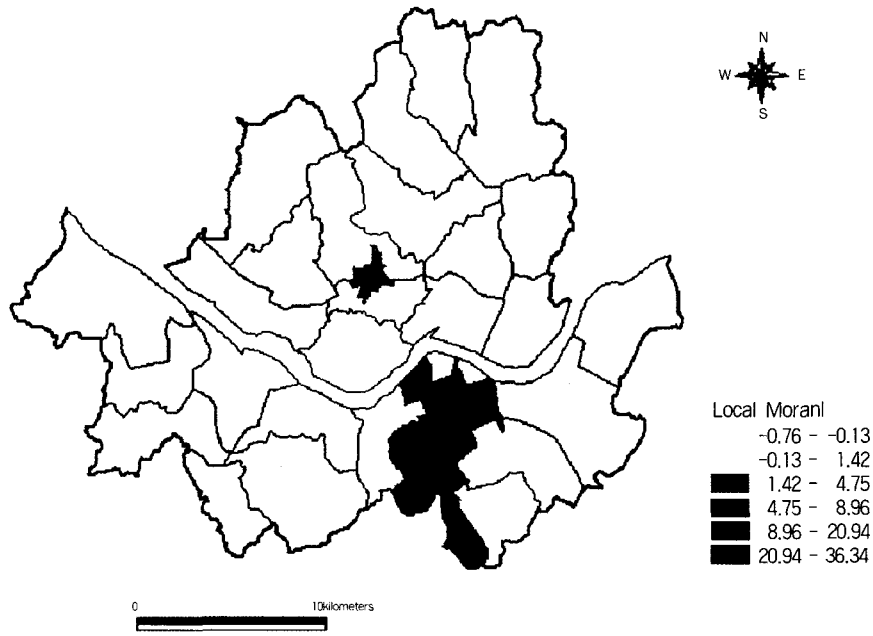

Figure 5. The spatial pattern of Local Moran's I for commercial domains

Thus, the location of commercial domains are interdependently influenced among adjacent *Dongs* in Seoul. This clearly indicates the fact that developed and underdeveloped *Dongs* for commercial

domains are located nearby forming spatial similarity in the development level of commercial domains. Therefore, Tobler's 'the first law of geography' about the fact that "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970: 236), is clearly applied to the case of commercial domains at the level of *Dongs* in Seoul.

Although the measures of Moran's *I* and Geary's *C* are useful in the identification of general spatial patterns, but these indices do not reveal the specific clusters of the location of commercial domains. Local Moran's *I* is a useful measuring to reveal the spatial patterns of clustering in spatially interdependented values. Figure 5 represents the pattern of Local Moran's *I* for commercial domains at the level of *Dongs*.

Four spatial patterns can be revealed by this figure. First, over 4.7 values for Local Moran's *I* are highly clustered in several *Dongs* of the Gangnam area, such as Yeoksam1, Yeoksam2, Seocho1, Seocho2, Seocho3, Dogok1, Nonhyeon1, Nonhyeon2, Samseong1, Samseong2, Sinsa *Dongs*. Thus, *Dongs* having a large amount of registered numbers for commercial domains are proximately clustered each other. Second, medium-high level values of Local Moran's *I*(1.4-4.6) are clustered in three adjacent *Dongs* of the CBD area such as Jongno1234, Myeong and Euljiro345 *Dongs*. And also, several *Dongs* of Gangnam are pertained in this level of values, which are surrounding *Dongs* in which the highest values of Local Moran's *I* are occurred. Third, *Dongs* with low values between 0.1-0.4 are also clustered together. Especially, the *Dongs* of this value level are quite closely located in the northern part of Seoul. Generally, these *Dongs* are pertained in the most underdeveloped areas in Seoul. Four, *Dongs* with minus level of Local Moran's *I* are also clustered together. In general, these *Dongs* are located in outside *Dongs* having the high and midium levels of Local Moran's *I*. Thus, the values of Local Moran's *I* clearly show clustering pattern among high, medium, and low values of commercial domains among *Dongs* of Seoul.

2) Factors Influencing on the Location of Commercial Domains

The previous part explores the spatial patterns of autocorrelation and also clustering in the development level of commercial domain inside Seoul. However, a measuring for spatial autocorrelation does not provide any estimation for the influencing factors for those geographies of commercial domain, thus regression analysis was carried out to estimate the influence of certain socio-economic factors for the development of commercial domain in Seoul.

Dependent variable was defined as the log transformed registered numbers of commercial domain, and socio-economic factors were setting as independent variables such as the number of establishment and employment in all industries, in producer services, in manufacturing, in cultural industries, and in wholesales and retails industries, and also independent variables included the number of university graduates, the level of educational attainment, the ratio of passenger car per 1000 population, and population[3]. From these independent variables, four variables, namely the number of producer service establishment, the ratio of university graduate, the manufacturing employment and the number of the establishment of cultural industry, were extracted via the stepwise method, with the consideration of multicollinearity among independent variables.

Table 3 shows the result of an ordinary least squares regression(OLS). All four independent variables are very highly significant and all variables are positively affecting the development of commercial domains. These four variables explain 57.4% of the total variance in the development of commercial domains in Seoul (R^2=0.574). From the information about the standardized coefficients(beta) of the independent variables, which serve as relative indices of strength, the number of producer service establishments represents the strongest relationship to the development of commercial domain. This variable alone accounts 49.8% of total variation in the devel-

Table 3. Results from ordinary least square regression model

	unstandardized coefficients(β)	standardized coefficient(beta)	standard error	t-value	significance
intercept	1.677	-	0.036	46.1	0.000
the number of producer services	0.00185	0.478	0.0002	12.0	0.000
the educational attainment level	1.528	0.264	0.1811	8.4	0.000
manufacturing employment	0.000034	0.157	0.0000	4.7	0.000
the number of culture industry	0.00266	0.149	0.0006	4.4	0.000

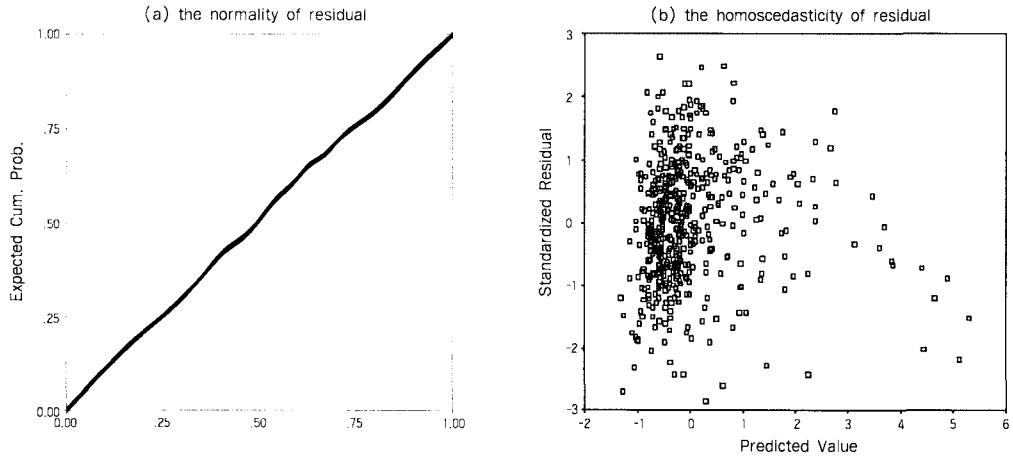

Figure 6. The fulfillment of the assumption for the linear regression model

opment of commercial domains at *Dong* level. Namely an increase of 1000 producer service establishments is estimated to induce the 478 new firms which have their commercial domains. Also, the level of educational attainment is more important than variables such as the number of manufacturing employment and of cultural industry's establishments in accounting for the variation in the development of commercial domains.

However, this extracted regression model must be fulfilled the assumptions underlying the linear regression model, if an inferential procedure is to be conducted. In order to evaluate the reliability and validity of a regression model, the following three assumptions are checked in this study; 1)whether the regression model is fulfilled as a normal distribution on residuals or not, 2)whether the regression model is fulfilled as homoscedasticity in the variances of residuals, 3)whether the regression model is fulfilled as non-spatial pattern for residuals or not.

Figure 6 shows the patterns of residuals related to normal distribution and homoscedasticity. The plot, representing the distribution of residuals or error values, perfectly shows a normal pattern. In addition, the variances of residuals are evenly distributed among standardized predicted values.

In addition, this research examines a residual analysis to detect the spatial autocorrelation in residuals. The residuals map of a ordinary least square regression model is shown in figure 7. This figure clearly shows the fact that (+) values of residuals and (-) values of residuals are proximately located each other. This residual map thus clearly shows the presence of spatially autocorrelated observations.

Moran's *I* measure for residuals yields a value of 0.3545, indicating the presence of a strong spatial autocorrelation with high values or low values of residuals are located near one another. Therefore, residuals observed by an OLS model pertain a high degree of spatial dependence. As a consequence the estimated relationship between dependent variable and independent variables may be biased or not reliable. This implies that some source of variation has been omitted from this OLS model.

In order to remedy a problem arisen from autocorrelation, this study utilizes a conditional spatial autoregressive model(CAR), since this CAR model offers an improvement over the problem of OLS model by incorporating a spatial lag into the modeling parameters. In other words, incorporating a spatial lag into a model can provide a better estimation for the spatial analysis of commercial domains.

Table 4 shows the result of a conditional spatial autoregressive model(CAR). Coefficients and standard error are represented as a highly significant level, but those values are not much changed compared to an OLS model. The standard error of residuals is lessen from 0.3249 in an OLS model to 0.3095 in a CAR model.

The most remarkable observation by this CAR model compared to an OLS model was the value of Moran's I. The value of the Moran's I decreased from 0.3545(OLS) to -0.1558(CAR) which is not significantly different from zero, representing no presence of spatially autocorrelated observations. A spatial autocorrelation on residuals is effectively eliminated with the use of a CAR model. Figure 8 represents the residuals map by a CAR model. Compared to the residuals map of an OLS model shown in figure 7, the spatial clustering of residuals between adjacent *Dongs* for commercial domains is lessened and no obvious spatial pattern can be shown.

As expected, the overall measure of the model was improved with the incorporation of a spatial lag variable. Therefore, a CAR model is a more useful measuring for a regression analysis than an OLS model, especially the former can effectively eliminate the problem caused by a spatial autocorrelation in an ordinary least square regression.

5. The Influences of Commercial Domains on the Changing Forms of the Urban Structure in Seoul

The locational patterns of registered commercial domains in Seoul show several important characteristics, influencing on the changes of the urban structure. Commercial domains have concentrated highly towards the major business districts, roughly defined by the CBD(Jung-*Gu* and Jongno-*Gu*), the Yeoungduengpo area, and the Gangnam area(Gang nam-*Gu* and Seocho-*Gu*). Even though, the share of commercial domains in these three centers has declined slightly from 63.2% in 1998 to 56.8% in 2002, but a concentration pattern is still dominant for commercial domains. The obvious difference in spatial patterns among these major business centers are

Table 4. The results of a conditional spatial autoregressive model

	coefficients	standard error	t-value	significance
intercept	1.700	0.039	43.56	0.000
the number of producer services	0.0019	0.0001	12.8	0.000
the educational attainment level	1.407	0.1850	7.6	0.000
manufacturing employment	0.000034	0.0000	5.0	0.000
the number of culture industry	0.00256	0.0006	4.4	0.000

* Likelihood = -1008; Rho = 0.2117

Figure 7. Residuals map by a ordinary least square regression model

Figure 8. The residuals map by a conditional spatial autoregressive model

the fact that the CBD and Yeongduengpo area is dominated by one or two *Dongs*, namely Jongno1234 and Euljiro345 *Dongs* for the former and Yeouido-*Dong* for the latter. However, several *Dongs* are shar-

ing a leading role in the development of commercial domains in Gangnam. The Gangnam area has been the most important place for the production and consumption of Internet related activities. Simply, 36.9% of firms which utilize commercial domains for the production and consumption of information are located in this area. This implies that Gangnam acts as a leading place for rapidly developing information intensive activities which are generally boosted by the development of the urban economy. This development of commercial domains in Gangnam is thus related to the cumulative effects formed by urban economies in general and economies of agglomeration in particular(Grimes, 2003; Malecki, 2002; Zook, 2000). For example, the advancement of Internet activities are closely related to the developmental conditions of a place such as qualified transportation and communication infrastructure, labor pool, and the growth of industries in general. Also, externalities arising from networking through the clustering of inter-related industries boost strongly the development of venture capital, and also the production and consumption of information intensive activities. Therefore, the development of commercial domains in Gangnam is coming from its advantages derived by the economies of urban and agglomeration. Also, some diseconomies of agglomeration occurred in the CBD may affect the development of commercial domains in Gangnam.

However, the development of commercial domains are also occurring some parts of Seoul. Even their shares in registered numbers of commercial domains are relatively low, several *Dongs* outside the major business districts were emerged as new business centers for the production and consumption of the Internet related activities, for example, Seogyo-*Dong* and Donggyo-*Dong* (Mapo-*Gu*), Oguem-*Dong* and Garak2-*Dong*(Songpa-*Gu*), Guro5-*Dong*(Guro-*Gu*), and Guui3-*Dong*(Gwangjin-*Gu*). This indicates the development of urban structure as a multi-centered form in Seoul, even though their roles are not predominantly occurring yet.

In the meanwhile, Internet related activities are strongly affecting a concentration at the intra-metropolitan level of Seoul. The top 10 *Dongs* comprise 28 % of the registered numbers of commercial domains in Seoul, and the top 20 *Dongs* 41.7 % at the end of 2002. This concentration is very clearly shown compared to their share in the number of population and of all industry establishments(Table 5). For example, the top 10 *Dongs* in commercial domains comprise only 8.3 % in the numbers of all industry establishments in Seoul.

Related to this concentration, 8 *Dongs* of the top 10 *Dongs* are located in Gangnam and another 6 *Dongs* of Gangnam are included in the top 20 *Dongs*. Thus, the concentration of commercial domains are mainly occurring in and around those 14 *Dongs* in Gangnam.

Therefore, a progressive development towards multi-nucleated urban structure in general, plus the concentration of commercial domains in Gangnam, strongly indicate the process of splintering urbanism inside Seoul. Major business areas inside Gangnam, located nearby Teheran-ro, emerges as a leading place for the Internet related activities, outpacing the traditional central business districts and increasing a gap with the other part of Seoul.

6. Concluding Remarks

This research attempts to reveal the spatial pat-

Table 5. The comparison of the top Dongs in commercial domains with their shares in population and numbers of all industry establishments (unit: %)

	Commercial Domains	Population	All establishments
Top 10 Dongs	28.0	2.2	8.3
Top 20 Dongs	41.7	3.6	13.1
Top 30 Dongs	50.0	5.3	19.9

Source: KRNIC, 2002, unpublished data on the registration of commercial domains; Seoul Development Institute, 2000, Thematic Maps of Seoul.

terns of commercial domains and also their spatial context through various spatial statistical methods. The spatial pattern of commercial domains shows highly concentrated one, namely 44% of commercial domains are located just in three places such as Gangnam-*Gu*, Seocho-*Gu*, and Jung-*Gu*. The most important spatial phenomenon is the development of commercial domains in the *Gangnam area*. Fourteen *Dongs* from the top 20 *Dongs* in the number of commercial domains are located in this area. Thus, these *Dongs* take a leading role in the development of production and consumption for Internet related activities in Seoul.

Thus, the emergence and development of the digital economy does not render automatically the diffusion of information intensive activities as like the arguments by some optimists on 'the death of distance' or 'the end of geography' through the expansion of the Internet. The location of registered commercial domains is thus not free from a spatial context.

The development of commercial domains represents a strong spatial autocorrelation among adjacent *Dongs* of Seoul. Even though a linear regression analysis is a useful method to extract the factors affecting the variation of the development of commercial domains, an ordinary least square regression(OLS) does not account for spatial dependence of variables. As this research reveals, the problem of a spatial autocorrelation has been remedied by using a conditional spatial autoregressive model(CAR). In other words, the incorporating of a spatial lag variable is very useful to eliminate the presence of spatial autocorrelation in residuals, improving the overall measure to remedy biased values in coefficients and standard error.

Through this study, it is found that the Internet activities is fixed to a spatial context and their spatial characteristics are interdependent among adjacent places. Therefore, the rapid growth of commercial domains is significantly influencing on the changes of the urban economy and of a spatial structure. The spatial dimensions of commercial domains represent a dynamic mix of concentration, and also some diffusion towards selected places. Thus, the location of commercial domains is highly responsive to the developmental level of economies of urban and agglomeration. Of course, the relationships between the growth of commercial domains and economies of urban and agglomeration are closely interrelated to cumulative causal processes. As a concluding remark, the location of the Internet related activities depends upon the quality of activities of a place, but also the Internet related activities influence strongly on the quality of activities of a place through their dynamic spatial dimensions of development processes.

Notes

1) The firms having commercial domains were geocoded by addresses based on the parcel number. The case which includes more than one firm in the same address, for example a building, was represented one dot in this figure.
2) Some *Dongs* are excluded in the top *Dongs* of location quotients owing to their low comprising in the establishment number of all industry, for example Cheongun-*Dong* in Jongno-*Gu* shows a very high value of LQ at 5.1, but it includes only 135 establishments in all industries.
3) Data for the number of establishment and employment in all industries, in producer services, in manufacturing, in cultural industries, and in wholesales and retails industries are based on the statistical tables(appendices) of *Thematic Map of Seoul 2000* published by Seoul Development Institute, and data for population, the number of university graduates and the level of educational attainment(the ratio of the graduates over university level to people of the age over 6) are based on Population and Housing Census 2000. Generally, the developmental level of industries and the number of population at the local area is important for firms which utilize commercial domains for the production and consumption of information. The human capital such as the number of graduates and the level of educational attainment is also viewed as a useful variable for an explanation of the selective location of firms having commercial domains.

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