Proceedings of the Ninth International Space Syntax Symposium
Edited by Y O Kim, H T Park and K W Seo, Seoul: Sejong University, 2013

A STUDY ON THE LEAD-LAG EFFECT OF SPATIAL CONFIGURATION AND ECONOMIC FACTORS:

Focusing on spatial configuration and the change of the hub of employment

085

Kyoung Yong Kim
Sejong university
e-mail: no5soon@naver.com

Young Ook Kim
Sejong university
e-mail: yokim@sejong.ac.kr

Abstract

The purpose of the study is to demonstrate the lead-lag effect of spatial configuration and economic and analyze the characteristics of the effect in Seoul. First, annual employment statistics are used for the analysis in order to know the periodic change of economic activity hub. Second, it analyzes the change in the spatial configuration with the maps of year 1971, 1981, 1991 and 2001 by utilizing space syntax. Also, it measures 10% (integration core) of the global integration map to analyze the hubs of spatial configuration. Third, time series analysis is employed by region to analyze the lead-lag effect of the hubs of spatial configuration and economic activity. Geographically Weighted Regression (GWR) analysis is also conducted by period to know the time lag. The analysis found that the spatial configuration almost coincides with the establishment of infrastructure by urban development, affecting the economic activity throughout time passage. Urban spatial configuration has the lead-lag effect of spatial configuration and economic factors and also time lag. This study suggests implications to be used in setting urban planning and policy guideline in confidence at the lead-lag effect. In addition, the changing forecast of economic activity will be useful on each period prediction of energy demand with existing research.

Keywords: *Space syntax, Spatial Configuration, Lead-lag Effect, Employment, GWR*

Theme: *Urban Space and Social, Economic and Cultural Phenomena*

1. Introduction

1.1 Context and Objective

As Bourne(1982) defined, there are the social, economic, physical and political factors that change urban structure. Particularly political factors have a great impact on it and infrastructure among the political factors plays a critical role in determining spatial structure. Due to the development of infrastructure by urban development, it becomes easier to move human and material resources. It increases accessibility to vicinity enhances to developed areas. And then it raises land price and brings in more advanced industries such as producer services. Like this, infra-structuring among the political factors changes spatial configuration and various social and economic factors change within the spatial pattern, continuing to interact with it (Bourne, 1991). Therefore, we can assume that there could be the lead-lag effect between spatial configuration and social and economic factors.

It is easy to detect the effect among the factors in industrial economic sectors. AF. Herbst(1987) could forecast the time of phenomenal events take place in stock market by analyzing the lead-lag effect between spots and futures. K. Hou(2007) analyzed the lead-lag effect among companies in industrial economy and could predict market shares. Because it is possible to predict the time of occurrence in the relation between two factors as mentioned, it is worth researching the lead-lag effect of spatial configuration and social and economic factors in this respect.

The previous two studies could predict the time of occurrence in terms of the relation between two variables, but the urban studies (Kim, 2009; Son, 2001) investigate the correlation analysis of the coincidence between spatial configuration and social and economic factors. Therefore, this study has an academic significance in that it can reveal the relation and characteristics of the lead-lag effect between spatial configuration and social and economic factors for the first time.

In this vein, this study aims to demonstrate the lead-lag effect of spatial configuration and economic factors and analyze its distinctions. To attain the objectives, the study has the following research contents. First, this study examines the changes of economic activity hub of economic factors on the basis of annual employment statistics data.*1* Second, it quantifies accessibility using space syntax, which allows us to see the hubs of spatial configuration, to investigate the change of urban spatial configuration by period. Third, time series analysis is employed by region to analyze the lead-lag effect of the hubs of spatial configuration and economic activity. Geographically Weighted Regression (GWR)*2* analysis is also conducted by period to know the time lag. This study can make some implications to be used in setting urban planning and policy guideline in future. In addition, the changing forecast of economic activity will be useful on each period prediction of energy demand with existing research.

1 The hub of employment can be used as one of the methods to identify the hub of economic activity.

2 GRW model uses micro- or local-level data to identify the spatial distribution of coefficients that the characteristics of each case have while general regression model usually uses the integrated data of a research to find single coefficient value by independent variable. (Brunsdon and Fotheringham, 1998)

1.2 Scope and Method

In the process of development, most of cities and towns change in terms of spatial configuration and social and economic factors. Especially for Seoul, the Korean government promoted urbanization plan in 1966 to tackle the development carried reckless out after Korean War. And it brought about many changes in terms of social and economic factors. However, the government didn't put in consideration the lead-lag effect of spatial configuration and social and economic factors in the process of urban planning and policy making. As a result, the regional imbalance of development accelerated as time went by. For the reason, it is worth choosing Seoul as the object of the research.

For this study, 4 different periods[3] were chosen over the last 40 years, which show the most obvious changes in the dimension of urban structure, to analyze the lead-lag effect between spatial configuration and economic factors of Seoul.

This study uses as spatial measure unit Seoul Traffic District Division that was set by then-Korea Transport Institute in 1990.[4]

This study analyzes the spatial configuration and the change of economic factors of Seoul and then the lead-lag effect of the configuration and the factors. To effectively display the contents of the research, ArcGIS was used. The research methods are as follows. First, the change of the economic activity hubs was analyzed with the annual employment statistics of 1981, 1991, 2001 and 2011. It was done so to know the economic trend of Seoul through employment density.

Second, space syntax was used to analyze the change of the spatial configuration with the maps of year 1971, 1981, 1991 and 2001. To do this, the hubs were ranked by the number of the axis line of 10% (integration core)[5] of the global integration map, which cross all the administrative districts of Seoul. It reveals the aspects of the change in the hubs of Seoul spatial configuration.

Third, time series analysis by area was employed to examine the lead-lag effect between the spatial configuration and the hubs of economic activity. A few of the districts, show considerable change in the rank of the hub, were chosen to be used for the time series analysis. Doing so allowed the comparison of the aspects of the change in the spatial configuration and the hubs of economic activity. Geographically Weighted Regression (GWR) analysis was conducted to analyze lag time by period in the lead-lag effect. The analysis used ArcGIS and looked quantitatively into the correlation between the spatial configuration and the hubs of economic activity, by period, from 1971 to 2011.

[3] Maps of Seoul were collectible for the year of 1971, 1981, 1991 and 2001. And 4 periods of employment statistics were collectible: 1981, 1991, 2001 and 2011. To examine the change of the population of employment in Seoul, the survey reports of overall business (1981, 1991) and the data of the total number of employment in the year books of ward office were used.

[4] The reason why traffic district is used as analysis unit is that the center or sub-center of city usually is not an isolated spot but more usually includes neighborhood geographically adjacent to it than the boundaries of 494 administrative districts which are too dense and close to one another. The traffic district division consists of 134 unit districts, combining 22 Gus (district) and 494 administrative Dongs (villages) of Seoul into one or several administrative Dong (small administrative unit).

[5] In general, integration core is referred to as the top 10 to 25% areas of the integrated map while segregation core covers the bottom 50% areas. The top 10 to 25% areas are used to examine spatial configuration and segregated areas. (Hillier and Hanson, 1984)

2. Review of the Literature

2.1 Review of Precedent Studies

The previous studies used different economic factors to determine the hubs of economic activity. Song(1997) used the density of employment and office total floor area to identify the hubs of Seoul from 1980s and 1990s. Jeon(1997) examined the potential interaction of areas on the basis induced traffic and then used it to identify the hubs of Seoul. There are other studies that used other indexes to identify the economic activity hub such a used land price, number of employees and data of financial institutions (Kim, 1992; Lee, 1996).

Table.1 A Study on the Change of the Hub of Economic Activity of Seoul (Kim, 2000, edited)

Index	**Analytical Method**	**Researcher**	**The Result**
Employment Density	Employment Density+Number of Employer	Song(1996)	4 Nuclei (heart of a city, Mapo, Yeuido) 2 Hubs of Employment (Younhdungpo-Guro, Dongdaemun)
Induced Traffic	Induced Traffic =(Unit of Traffic Source by Business Type x Number of Worker)/Area Size	Jeon(1997)	6 Sub-Centers (Kangnam, Youngdungpo, Mapo, Jaegi 1 Dong, Dapshimri 5 Dong, Song Pa)
Office	Total Floor Area of Office/Area Size	Song(1996)	4 Nuclei (Center, Mapo, Yeuido, Kangnam), 2 Hubs of Employment (Younhdungpo-Guro, Dongdaemun)
Land Price	The Highest Land Price by Unit Area	Kim(1992) Lee(1996) Chae(1997) Son, Nam(2006)	3 Sub-Centers (Kangnam, Youngdungpo, Chungryangri)
Others	Commercial Concentration Index	Kim, Kim(1981)	5 Layers of Commercial Districts
	Occupational Density =(Number of Voluntary Commuter/Area Size)	Ha , Kim(1992) Jeong, Kim(2002) Jeon, Jeong(2003)	7 Sub-Centers (Youngsan, Chungryangri, Shinchon, Yeuido, Younhdungpo, Guro, Kangnam)
	Number of Employee or Land Price, and Centrality Index of Variables Related to the Functions of the Center of a City	Kim(1992)	6 Sub-Centers (Younhdungpo, Kangnam, Shinchon, Chungryangri, Jamsil, Namyoung)

The review of the existing studies regarding the spatial configuration of Seoul is as follows. Lee(2001) studied the relation to urban type and functions of the spatial configuration of Seoul and the change of the spatial configuration. Kim(2012) compared the changes of urban space structure of Seoul and Pyungyang, focusing on the formation period of the hub, by using space syntax theory. Kim(2009) carried out a correlation analysis between the spatial configuration and economic factors of Seoul for the periods from 1970 to 2000.

As seen here, considerable number of studies has been conducted to conclude that there are interaction between spatial configuration and economic factors. However, a study hasn't been executed yet on the lead-lag effect of spatial configuration and economic factors.

2.2 Urban Planning of Seoul

In 1960, the population of Seoul exceeded over 2.5 million, but its urban structure was still confined in the state of 1950s. As the government established the 5-Year Economic Development Plan and labor-intensive export industry policy, population concentration accelerated (Kim, 2001). Population concentration caused Seoul to be congested. To tackle the problem, the government planed to establish 'Urban General Development Plan' in 1966. For the core areas of the plan, it set one center and 5 sub-center system (Changdong, Cheunho, Youngdungpo, Eunpyung, and Kangnam) (Sun, 2009).

As the population of Seoul grew over 5 millions in 1970, the overpopulation got worse. To relieve overpopulated Seoul, the government established various urban planning. The Seoul urban plans of 1970s consisted of one mononuclear downtown[6] and 7 sub-centers (Mia, Mangwoo, Kangnam, Youngdungpo, Eunpyung, Chunho, and Whakok). These sub-centers were intended to disperse population and functions. Kangnam area among the sub-centers was partially endowed with administrative functions. The government planed to establish legislative function and new business district in Yeuido.

Seoul had the greatest change in its urban configuration in 1980s. During the periods, Seoul Three Nucleuses Urban System, which began from 1907s, started spatial change and multinuclear urban[7] development policy began to accelerate in earnest. Seoul was reorganized into a city of a mononuclear (center), 3 sub-nucleuses (Kangnam, Youngdungpo, Jamsil), 13 sub-centers and 50 districts (Kim, 2011). Yeuido was developed to play a role as business function area; Youngdungpo for service functions; Mokdong as business-centered district; Taehyeran Road in Kangnam was designated as a large-scaled business district; and Jamsil was developed as logistic business complex area. Especially Kangnam development, which started from 1970s, attracted population from concentrated Kangbuk areas, making the population rate of both regions similar.

The urban spatial policy in 1990s succeeded 4 nucleuses and 13 sub-centers of 1980s. 4 nucleuses were (i)Jongro-Gu, (ii)Jung-Gu region, Youngdungpo and Yeuido area, (iii)Kangnam area and (iv) Jamsilarea. Multi- nuclear urban configuration plan was promoted to raise self-sufficiency by life zone and encourage balanced regional development (Cho, 1995).

6 Mononuclear town: It has one CBD. Mononuclear Town Theory assumes that overall industries are housed in the center of the downtown.

7 Multinuclear town: It is an urban spatial structure with more than one center. In multi-center urban model theory, the location of a sub-center is exogenously given. Some scholars distinguish multinuclear city from multi-center city in terms of their functions and perspectives, but most related literatures use both terms for the same purpose. Therefore this study doesn't separate them from one the other.

The urban general development plan of 1960s to solve the overpopulation of Seoul chose the multinuclear urban system but was insufficient in institutional devices to actualize it (Kim, 1998). As the urban general development plan gradually settled down and got materialized, the urban structure changed to multinuclear structure. The street network also developed from radius-circular type to grid type, accelerating the development of multinuclear town along with the development of subway and underground network systems (Jeon, 2001).

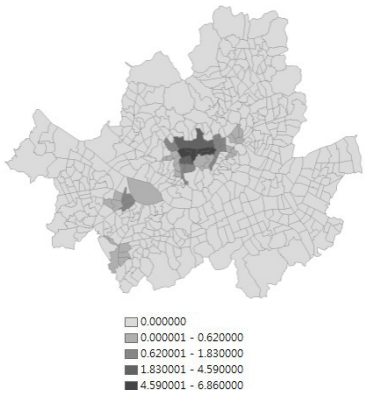
Table.2 The Transition of Seoul Urban General Development Plans(Kim et al, 1998, edited)

Period	Name of Plan and Year	Spatial Plan	Urban Structure Plan	Street Network
1960s	①Urban General Development Plan(1966)	Functional Division of Center and Sub-Center	One center and 5Sub-Centers	Radial Type
1970s	①Revised Urban General Development Plan(1970) ②Corrective Comprehensive Plan(1972) ③Seoul Urban General Development Plan for 2000s(1978)	- Strategic Dispersion Development of Sub-Centers - Idea to Establish Multinuclear Town	1Nucleus , 7Sub-Centers	Radius Circular Type
1980s	①Long-Term and Mid-Term Seoul Urban Development Plan(1980) ②Multinuclear Town Development Research for Urban Structure Reorganization(1984)	- Change in Multinuclear Stricture - Idea to Plan Metropolitan City Due to the Metropolitanization of Seoul	1Nucleus, 3Nucleuses, 13Sub-Centers, 50Districts	Grid-Radial Circular Type
1990s	①Urban General Development Plan for 2000s(1990) ②Seoul Urban General Development Plan(1997)	- Reinforce the Connect between Center and Sub-Center - Compound Use of Land - Balanced Development of Kangnam and Kangbuk	1Nucleus, 4Sub-Centers, 11Local-Centers, 54Districts	Street Network Organically Connected to Multinuclear Structure

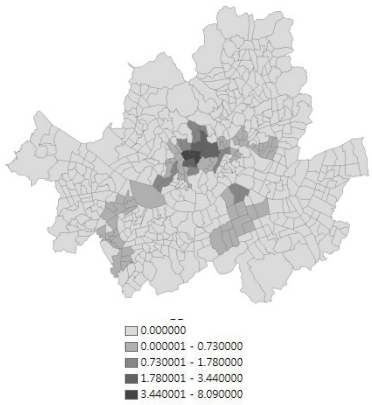
3. Findings and Discussion

3.1 Analysis of the Change of Seoul Economic Activity Hub by Period: Focusing on Employment Density

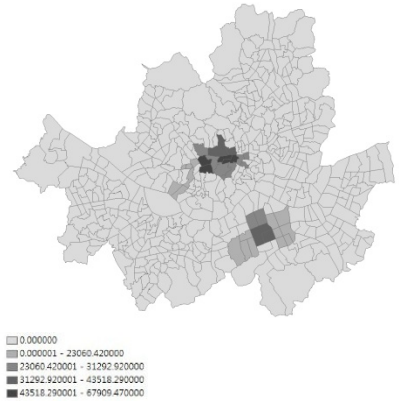
This chapter looks into the trend of Seoul economic activities through employment density. For this analysis, the annual employment statistics of 1981, 1991, 2001 and 2011 were used. Although Song(1997) carried out the analysis for 1981 and 1991, it was difficult to use the data for the analysis of lead-lag effect due to the insufficient number of years. To conduct lead-lag effect, 40-year data, from 1981 to 2011, was needed in total to analyze the change of employment hubs. Therefore, this study carried out addition analysis, including 10-year data of Seoul employment hubs(2001-2011).



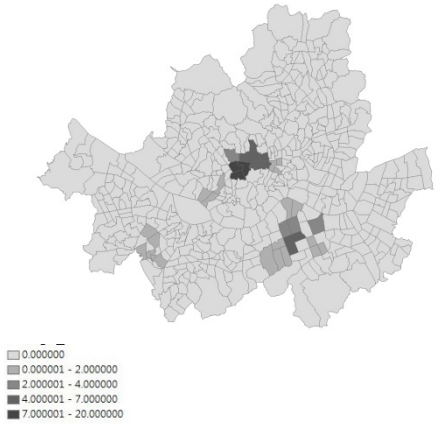
The Distribution of Seoul Employment Hubs in 1981 (Song, 1997)



The Distribution of Seoul Employment Hubs in 1991 (Song, 1997)



The Distribution of Seoul Employment Hubs in 2001



The Distribution of Seoul Employment Hubs in 2011

Figure.1 The Distribution of Seoul Employment Hubs

When we define the areas of which employment density is 2 times higher than the average as employment hub according to Green's criteria (1980), it was confirmed that Seoul had 22 employment hubs in 1981, 34 hubs in 1991, 15 hubs in 2001 and 16 zones in 2011. The employment hubs of 1981 were mainly located in Jung-Gu and Jongro-Gu. Besides them, Youngdungpo and Guro-Gu were included. The number of employment hub in 1991 increased by 12 from 1981 and the average rate of employment density also increased by 25.5%. Kangnam-Gu and Seocho-Gu were the main zones of the employment hub of 1991, which appeared newly. Other than these, it was observed that the hub radius of Dongdaemun-Gu, Youngdungpo-Gu and Guro-Gu had expanded.

Table.3 Economic Activity Hub of Seoul

		Jongro-Jung-Gu	Kangnam-Gu	Yeuido-Youngdungpo-Gu	Mapo-Gu	Dongdaemun-Gu	Guro-Gu	Economic Activity Hub	Total Seoul
1981	Area[㎢] (Proportion[%])	19.18 (3.15)		12.32 (2.0)		2.24 (0.37)	6.55 (1.06)	40.29 (6.60)	605.43 (100)
	Number of Employee, Person (Proportion[%])	885,992 (37.19)		132,580 (5.56)		24,039 (1.01)	90,254 (3.79)	1,132,885 (47.55)	2,382,536 (100)
	Classification	Central Area		Sub-Central Area		Employment Hub	Employment Hub		
1991	Area[㎢] (Proportion[%])	20.59 (3.39)	21.11 (3.49)	9.80 (1.61)	3.81 (0.63)	2.24 (0.37)	15.77 (2.60)	77.45 (12.78)	605.43 (100)
	Number of Employee, Person (Proportion[%])	885,833 (24.39)	368,756 (10.15)	203,865 (5.62)	90,010 (2.48)	24,039 (1.01)	232,196 (6.39)	1,864,437 (51.34)	3,632,234 (100)
	Classification	Central Area	Employment Hub	Sub-Central Area	Sub-Central Area	Employment Hub	Employment Hub		
2001	Area[㎢] (Proportion[%])	9.6 (1.59)	19.36 (3.19)		2.89 (0.48)			31.85 (5.26)	605.43 (100)
	Number of Employee, Person (Proportion[%])	452,035 (12.49)	480,359 (13.27)		65,361 (1.8)			997,755 (27.56)	3,620,126 (100)
	Classification	Central Area	Sub-Central Area		Employment Hub				
2011	Area[㎢] (Proportion[%])	9.58 (1.58)	21.39 (3.53)		2.48 (0.41)		6.76 (1.12)	40.21 (6.64)	605.43 (100)
	Number of Employee, Person (Proportion[%])	493,853 (11)	663,337 (14.77)		52,210 (1.16)		142,261 (3.17)	997,755 (30.1)	4,490,081 (100)
	Classification	Central Area	Sub-Central Area		Employment Hub		Employment Hub		

Particularly, the employment hub of Mapo-Gu was connected to the center of Seoul and Yeuido, forming an axis of a massive employment hub (Song, 1997). Although the employment hub of 2001 decreased by 19 in number from 1991, the employment density increased by 51.4%. It suggests that employment density increased and thus the hub decreased in Seoul as a whole. Also, it is though that the employment density of Jung-Gu decreased while that of Kangnam-Gu increased, dispersing employed population. The employment hubs of 2001 were Jung-Gu,

Kangnam-Gu, Seocho-Gu and Mapo-Gu, which were similar to those before, but Dongdaemun-Gu, Youngdungpo-Gu, and Guro-Gu were delisted from the distribution map of employment hub. In addition, the employment hubs of 2001, different from those of 1991, shrank and its axis disappeared at the same time.

The hubs of 2011 had one more zone than those of 2001 and its overall density increased by 15.8%. It can be said that the change in the employment hub and density was obvious from 1980 to 2001 while that from 2001 to 2011 was less obvious. The employment hubs of 2001 were Jung-Gu, Jongro-Gu, Kangnam-Gu, Seocho-Gu and Mapo-Gu. Guro-Gu, which was the hub in 1991, was added.

<Table.3> was analyzed on the basis of the data of employment hubs. It was observed in 1981 that there were 1 center (Jung-Gu and Jongro-Gu), 1 sub-center (Youngdungpo-Gu), and 2 employment hubs (Dongdaemun-Gu, Guro-Gu). The total size of those center, sub-center and hubs took 6.6% of the total size of Seoul or 40.29Km^2. 47.6% (or 1,132,865 employees) of the total employees worked in those areas. In 1981, the center of Seoul took 3.15% of the total Seoul land size but 37% of the total Seoul employees was concentrated in the zones, which means high importance of the center. Through the data, it can be known that population of employment had already been dispersed, but major business and management functions were still rooted in the center. Especially Youngdungpo (sub-center) including Yeuido showed that it took merely 5% of the total Seoul employment, which is very minor (Song, 1997).

It was observed that there were 1 center (Jung-Gu and Jongro-Gu), 3 sub-centers (Kangnam-Gu, Mapo-Gu, Youngdungpo-Gu), 2 employment hubs (Dongdaemun-Gu, Guro-Gu) in 1991. The change implied that multinuclear trend had started. The growth of such sub-centers can be understood as the results from good location for companies t make profit and from the supply of traffic facility and land policy by the government. In particular, it is thought that the change in the urban structure of Seoul for 10 years (1980 -1990) is attributed mainly to the urban developments (Song, 1997).

In 2001, it was confirmed that there were 1 center (Jung-Gu, Jongro-Gu) and 2 sub-centers (Kangnam-Gu and Mapo-Gu). It was found that there was a shift of the hub as the number of employer and the size of employment hub in the center got lower than those of the sub-center. The phenomenon can be explained by the reversal phenomenon that the consistent development of Kangnam such as large-scaled and excellent housing complexes and offices induced population from the center to Kangnam. Also, the picture of 2001 showed that the center of Seoul took 5.26% (increased than before) of the total Seoul land size and 27.56% (decreased than before) of the total Seoul employees, which evidenced that the potions of the center decreased from the past. Because of this, there was the aspect that employed population dispersed all over Seoul areas.

In 2011, it was confirmed that Seoul had 1 center (Jung-Gu, Jongro-Gu), 2 sub-centers (Kangnam-Gu and Mapo-Gu) and 1 employment hub (Guro-Gu). It seemed that the hubs of Seoul economic activity were similar to those of 2001. It implies the slower growth of urban development than before. As one of the urban characteristics in 2011, the inverse phenomenon of the center and sub-center of Kangnam accelerated. Although the Urban General Development Plan intended to develop Kangbuk in an attempt to solve the imbalanced regional development between Kangnam and Kangbuk ever from 2000, the number of employees in Kangnam more increased than that in Kangbuk. (Kim et al, 2001) Another was the re-inclusion of Guro-Gu in the list of employment hub. It was because the government led the development of high-tech IT industrial complex in the area from 2000s. Guro-Gu had played a role as the

complex of manufacturing industry till 1990s but the number of manufactures had decreased due to the change of industrial structure after then (Wikipedia, “Guro-District”).

3.2 Analysis of Change of Seoul Spatial Configuration by Period

This chapter examines the change of aspects of Seoul spatial configuration. For this analysis, space syntax was employed together with the maps of 1971, 1981, 1991, 2001. The analytical method of the change of spatial configuration hub was based on ranking by the number of the axis line of 10% (integration core) of the global integration map, which cross all the administrative districts of Seoul. This study aims to look into the aspects of the change in the hubs of Seoul spatial configuration.

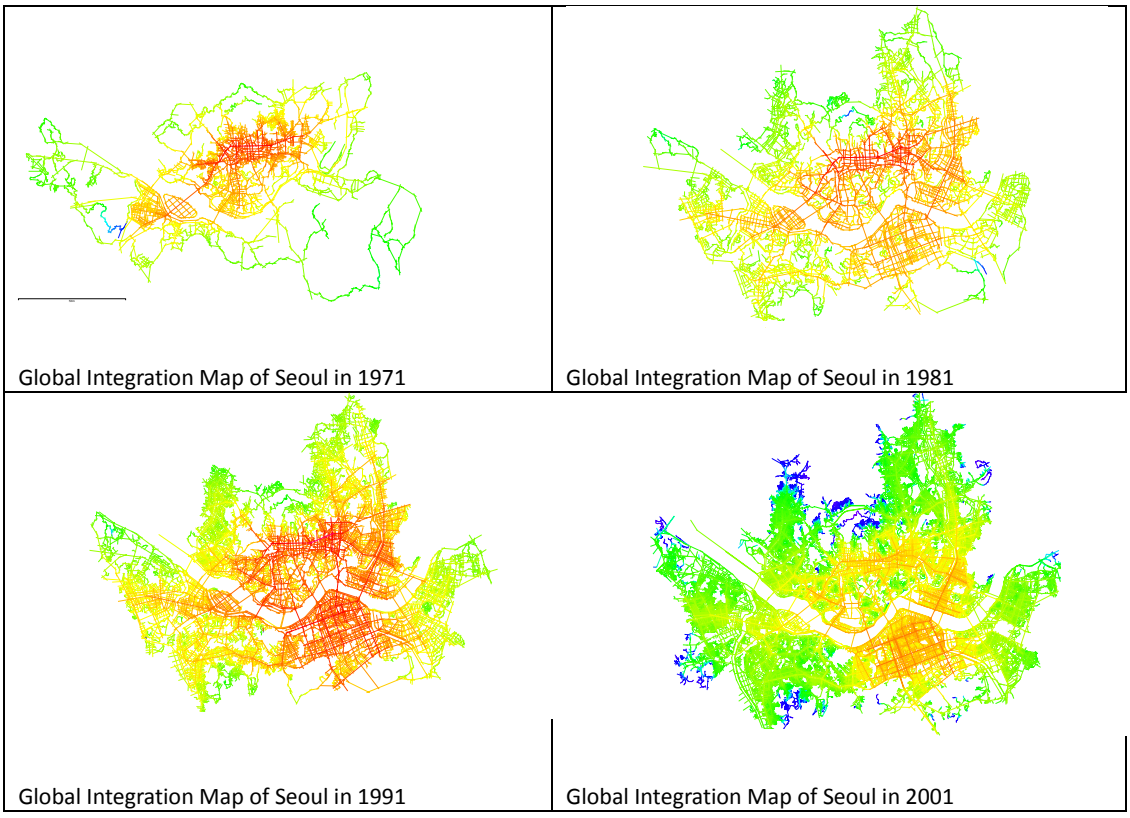
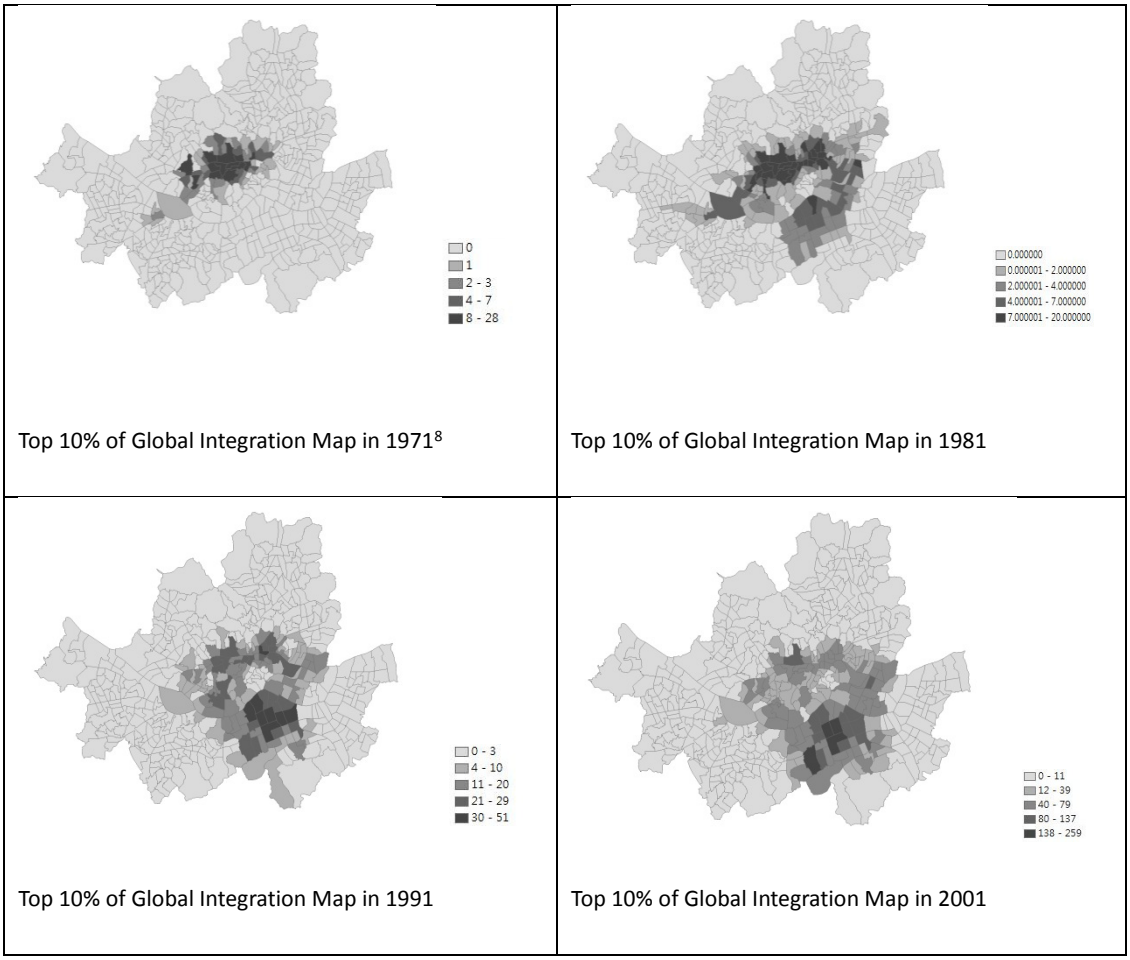


Figure.2 Global Integration Map of Seoul



Top 10% of Global Integration Map in 1971[8]

Top 10% of Global Integration Map in 1981

Top 10% of Global Integration Map in 1991

Top 10% of Global Integration Map in 2001

Figure.3 Top 10% of Global Integration Map

In 1971, Seoul had 2,867 axis lines and the average of global integration was 0.62. In global urban configuration of Seoul, Jongro was 0.98, which means it has a high accessibility and was an important road that crossed Seoul from east to west. In 1971, the entire areas of Jongro had a highest integration, which easily tells it was the center of Seoul. Another worth noticing is Mapo main road whose integration was 0.88. It was an axis to bridge between Kangnam and Kangbuk. It explains that as Seoul became industrialized, growing fast, the diverse urban functions were naturally dispersed and the policies to transfer them were taken. In addition, Yeuido and Youngdungpo development plan were executed as one of dispersing policies, which began from 1968 (Kim, 2012). After the Yeuido development, another Yeuido and Youngdungpo development was carried out to develop the regions south of Han River. Because of this, the integration value of Mapo main road increased, which bridges between Jongro and Yeuido.

In 1981, Seoul had 4,797 axis lines and the average of global integration was 0.65. In global urban configuration of Seoul, the area with the highest integration value was Jongro (0.98). In 1981, Seoul authority designated Jongro as its center on the basis of the Urban General Development Plan in 1981. Thus, the spatial configuration hub was also Jongro. From the analytical result of top 10% spaces of the global integration map, we see that Jongro-Gu, Youngdungpo-Gu, Kangnam-Gu, and Dongdaemun-Gu were distributed in it. It can be explained by the sincere execution of the large-scaled housing site preparation projects of the southern

[8] The number of the axial line of top 10% of the integrated map that crosses administrative district unit

areas of Han River such as Kangnam area development and Jamsil zone development, which planed to accommodate 600,000 persons on total 26.4km^2, Kangnam Development Promotion Policy (Kim, 1991).

In 1991, Seoul had 9,355 axis lines and the average of global integration was 0.75. In global urban configuration of Seoul, the area with the highest integration value was Jongro and Wangsanro, which covered from Dongdaemun Station to Youngdu-Dong crossroads. Their value was 1.08. Although the Jongro zone located through Jongro 1·2·3·4·5 Rd used to have the highest integration till 1981, it appeared in 1991 that the center moved to the east of Jongro.

In the meantime, the integration of Dongdaemun-Gu increased that bridges Jongro (the center of Seoul) to Kangnam (the sub-center). The roads of the second highest integration were Shinbanpo road and Hankdong road, which extend from Kangnam Ward Office Station to Shinbanpo Station. Their global integration was 1.08. In the beginning, Kangnam was a bed town, severely lacking in autonomous basic living facilities, so it relied heavily upon Kangbuk. However, as Kangnam 8 school districts and Kangbuk Control Measure, which was one of the strong military regime policy, went into good effect, those areas emerged as new core zones that enjoyed monopolistic benefit from the growth of Seoul (Lee et al. 2011) and also they were classified as core zone in the spatial configuration. The roads of the third highest global integration was the Jongro area located through Jongro 1·2·3·4·5 Rd, of whose global integration was 1.08.

The reason why the rank of Jongro spatial configuration decreased was the concentration of large-scaled good housing complexes and offices in Kangnam due to the persistent development of Kangnam, which caused the imbalance of regional development. From the analyses of the top 10% of global integration, it was found that more than 60% of axis lines appeared in Kangnam and Jamsil areas. Subcenter of two Kangnam, Jamsil area is set to take place there was centered in space structures. The government is set to city center Jongro area, but urban spatial configuration were analyzed Kangnam, Jamsil area of the central region.

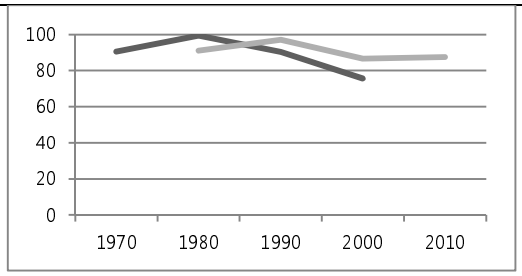
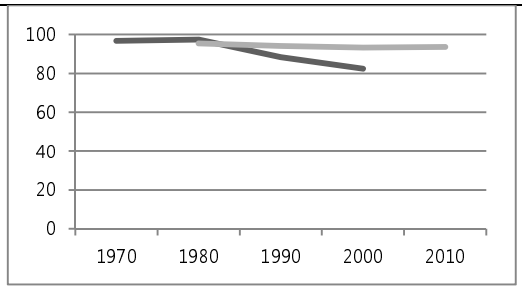
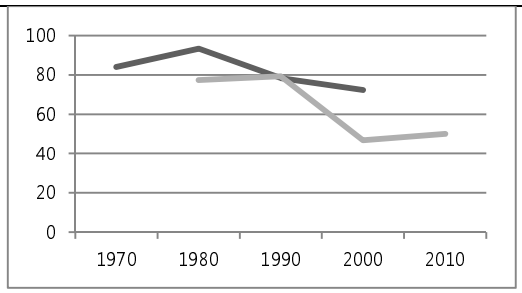
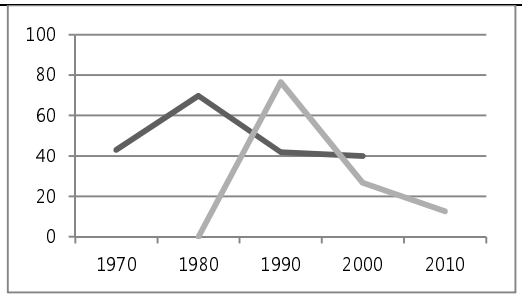
In 2001, Seoul had 54,079 axis lines and the average of global integration was 0.61. In global urban configuration of Seoul, the zone with the highest integration value was Shinbanpo road and Hakdong road from Kangnam ward Office Station to Shinbanpo Station (0.91). Most of roads with high integration were distributed in Kangnam areas. Jongro, which used to rank high in the spatial configuration, was on the 55th. In addition, from the analytical result of top 10% spaces of the global integration map, we see that more than 70% of axis lines are concentrated on Kangnam and Jamsil areas, whose value is 10% higher than that of 1991. Resultantly, it means that the government attempted a balanced urban development plan for the imbalance between Kangnam and Kangbuk, but it didn't work (Kim, 2011). The imbalance more accelerated during the period.

3.3 Time Series and GRW Analysis of the Hubs of the Spatial Configuration and Economic Activity of Seoul

3.3.1 Time Series Analysis by Area

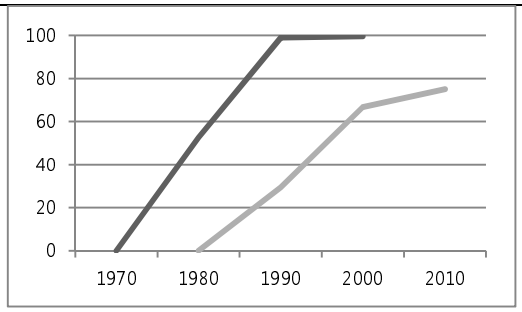
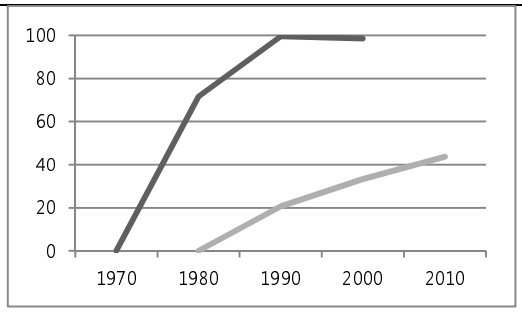
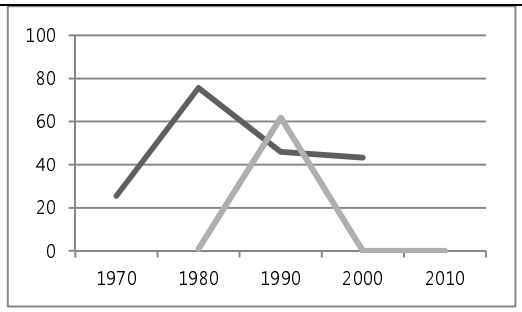
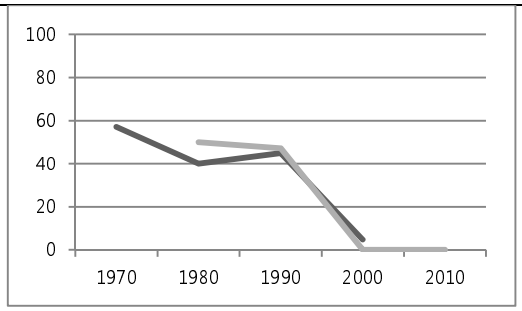
This chapter compares the changing aspects of the hubs of the spatial configuration and economic activity of Seoul. This analysis was based on the table of time series analysis by representative area chosen from each district

Table.4 Time Series Analysis by Area

Administrative Dong **(Administrative District)**	**Factor**	**1971**	**1981**	**1991**	**2001**	**2011**	**Time Series Graph**
Sokong-Dong (Jung-Gu)	Rank of Spatial Configuration Hub [9]	6/63 (9.5%)	1/152 (0.6%)	19/198 (9.6%)	51/210 (24.3%)		
	Rank of Economic Activity Hub [10]		2/22 (9%)	1/34 (2.9%)	2/15 (13.3%)	2/16 (12.5%)	
Taepyung Rd 1 Myung-Dong (Jung-Gu)	Rank of Spatial Configuration Hub	2/63 (3.2%)	4/152 (2.6%)	23/198 (11.6%)	37/210 (17.6%)		
	Rank of Economic Activity Hub		1/22 (4.5%)	2/34 (5.9%)	1/15 (6.7%)	1/16 (6.3%)	
Sajik-Dong Seijong Rd (Jongro-Gu)	Rank of Spatial Configuration Hub	10/63 (15.9%)	10/152 (6.6%)	43/198 (21.7%)	58/210 (27.6%)		
	Rank of Economic Activity Hub		5/22 (22.7%)	7/34 (20.6%)	8/15 (53.3%)	8/16 (50%)	
Kongduk-2Dong New Kongduk-Dong Dowha-1and 2Dong Younkang-Dong (Mapo-Gu)	Rank of Spatial Configuration Hub	36/63 (57.1%)	46/152 (30.3%)	115/198 (58.1%)	126/210 (60%)		
	Rank of Economic Activity Hub			8/34 (23.5%)	11/15 (73.3%)	14/16 (87.5%)	

[9] (Rank of Spatial Configuration Hub by Area / Lowest Rank of Spatial Configuration Hub by Area) X 100

[10] (Rank of Economic Activity Hub by Area / Lowest Rank of Economic Activity Hub by Area) X 100

Yeoksam 1·2Dong (Kangnam District)	Rank of Spatial Configuration Hub		72/152 (47.4%)	2/198 (1%)	1/210 (0.5%)		
	Rank of Economic Activity Hub			24/34 (70.6%)	5/15 (33.3%)	4/16 (25%)	
Nonhyun-Dong Hak-Dong (Kangnam District)	Rank of Spatial Configuration Hub		43/152 (28.3%)	1/198 (0.5%)	3/210 (1.4%)		
	Rank of Economic Activity Hub			27/34 (79.4%)	10/15 (66.7%)	9/16 (56.3%)	
Yeuido-Dong (Youngdungpo District)	Rank of Spatial Configuration Hub	47/63 (74.6%)	37/152 (24.3%)	107/198 (54.0%)	119/210 (56.7%)		
	Rank of Economic Activity Hub		22/22 (100%)	13/34 (38.2%)			
Youngdungpo 1,2,3Dong (Youngdungpo District)	Rank of Spatial Configuration Hub	27/63 (42.9%)	91/152 (59.9%)	109/198 (55.1%)	200/210 (95.2%)		
	Rank of Economic Activity Hub		11/22 (50%)	18/34 (52.9%)			

<Table.4> shows the rate of change by area in the ranks of the hubs of the spatial configuration and economic activity from 1971 to 2011. It is confirmed that the areas in Jung-Gu are constantly positioned in high ranks of the hubs of the spatial configuration and economic activity. It evidences that the Urban General Development Plans had been focused on Jung-Gu areas since 1960s.

However, their ranks started being pushed down in the hub ranks of the spatial configuration from 1990 and in the hub ranks of the economic activity from 2000. The reason for the dropdown can be explained by the inversed phenomenon in the rank of the spatial

configuration hub due to Kangnam development. The same inversed trend began to happen for the hub of economic activity in 2000. The areas in Mapo-Gu had gradually had higher integration due to Yeuido and Youngdungpo development, which started in 1968 and their ranks in the economic activity hub started to rise, 10 years later, from 1980. However the rank of Mapo-Gu in the spatial configuration hub lowered in 1990 due to Kangnam development and in 2000, 10 years later, its rank in the economic activity hub also dropped down.

In the meantime, the rank of the areas in Kangnam-Gu gradually rose in both the spatial configuration and economic activity. Notably, the rank of the economic activity hub started to rise from 10 years later. This time lag can be explained by the initial characteristics of Kangnam development which focused on highly dense apartment complex first and shifted the focus from housing to commercial and office buildings from 1970s (Seo, 2008). Kangnam was designated as a sub-nucleus in the Urban General Development Plan in 1980s and continued to developed ever since. As a result its rank kept rising in the process. The areas in Yeuido show a similar picture to those in Mapo-Gu.

It explains that Yeuido was affected by Yeuido and Kangnam development in a similar way that Mapo-Gu was. 10-year time lag was also observed in the time series graph of Yeuido areas. When Yeuido was developed in 1968, the development plan concentrated first on building a cluster of apartment. It formed purchase power in it and this invited more commercial faculties into the areas (Park, 2011). After the National Assembly Building was founded in 1975 in Yeuido, financial and broadcasting companies entered into the areas and skyscrapers were built in 1985, making the employment density of the areas rise (Ahn, 2009). Particularly the areas of Yeuido 1·2·3 Dong show the rise of the hub rank of the spatial configuration coincides with that of the economic activity.

In 1970s, Youngdungpo settled down as an industrial city as manufacturing industry boomed, absorbing population. As a result, a massive consumer market was formed (Kazuhiro et al. 2009). However, as it tuned to 1990s, labor dispute and demand of wage rise by laborers aggravated profitability, again leading to the sluggish export. Manufacturers started to disappear in the areas. It was conformed through the analysis by the autonomous district of Seoul that Youngdungpo was the place where factory was transferred most often, pushing down the number of employees rapidly (Kim, 2010). Therefore, it seems there was the lead-lag effect in the areas but the time lag was very insignificant. It suggests that the district was affected more by industrial structure than spatial configuration.

Youngdungpo areas except its 1·2·3 Dong show that the higher the rank in the spatial configuration hub was, the higher the rank in the economic activity hub is and vice versa. Also, there was 10-year time lag between the spatial configuration hub and economic activity hub.

3.3.2 GWR Analysis by Period

This chapter quantitatively examines the correlation between of the hubs of the spatial configuration and economic activity of Seoul from 1971 and 2011. In addition, it looks into the time lag in the lead-lag effect.

Table.5 Geographically Weighted Regression Analysis by Period(R^2)

		Spatial Configuration Hub			
		1971	1981	1991	2001
Economic Activity Hub	1981	0.75	0.59		
	1991		0.65	0.59	
	2001			0.59	0.63
	2011				0.62

<Table.5> is the table of GWR analysis by period on the hubs of the spatial configuration and economic activity from 1971 to 2011.

The GWR of the economic activity hub of 1981 is 0.75 for the spatial configuration hub of 1970 and 0.59 for the spatial configuration hub of 1981. It turned out that the GWR of the economic activity hub of 1981 is higher by 0.16 for the spatial configuration hub of 1970 than for 1981. The GWR of the economic activity hub of 1991 is 0.65 for the spatial configuration hub of 1981 and 0.59 for the spatial configuration hub of 1992. It turned out that the GWR of the economic activity hub of 1992 is higher by 0.06 for the spatial configuration hub of 1981 than for 1992. Also, the GWR of the economic activity hub of 2001 is 0.59 for the spatial configuration hub of 1992 and 0.63 for the spatial configuration hub of 2003. The GWR of the employment hub of 2011 is 0.62 for the spatial configuration hub of 2003. As a result, it turned out that the economic activity hubs of 2001 and 2011 are more correlated to the spatial configuration hubs of 2003.

The Korean government established urban development plans to restore the devastated cities by Korean War. In the process, the urban space structure of Seoul had changed notably from 1960s to 1990s. The rapid change of the spatial configuration was interlinked with the hubs of the economic activity in the lead-lag effect relation by which the economic activity hubs changed, usually, in 10 year later. In 1990s, most areas of Seoul developed and so since than there wasn`t much change in the spatial configuration until 2000s. During this time period, both variables had the lead-lag effect relation but time lag became shortened.

As a result, when a city develops rapidly, time lag exists because of the lead-lag effect between the hubs of spatial configuration and economic factors. Here, it is predicted that the spatial configuration has a great impact on the economic activity hub. In the meantime, when a city develops slowly, time lag exists but it gets shortened. Here, it is predicted that the extent of effect of the spatial configuration on the economic activity hub is weakened.

4. Conclusion and Extended Suggestions

This study aims to identify the lead-lag effect of spatial configuration and economic factors. It examined Seoul for the changes in employment hub, spatial configuration and the lead-lag effect. The findings are summarized as follows.

First, the economic activity hubs of Seoul were analyzed with employment density statistics. It showed that the economic activity hubs changed from mono-nucleus to multi- nucleuses during 1980s to 1990s. Urban development was the main attribute to the change. As the urban growth gradually reached the complete stage from 2000s to 2010s, there was little change in the hubs of Seoul economic activity. However the persistent Kangnam development made the area more concentrated as a hub even after the completion of the development. As a result, Kangnam areas replaced Joro-Gu and Jung-Gu for the center of Seoul of highest economic activity. Therefore, it can be known that economic activity hub is influenced by the growth rate of urban development.

Second, the spatial configuration hubs of Seoul changed from mono-nucleus to multi- nucleuses in 1980s, which is 10 years earlier than the hubs of economic activity. The change of the spatial configuration is mainly attributed to the establishment of infrastructure by urban development. As urban growth became slower from 1990s to 2000s, the spatial configuration hadn't changed much. The configuration showed a very similar picture as the economic activity, which space was more concentrated in Kangnam areas due to the consistent development of Kangnam. Therefore, it is known that the hubs of spatial configuration is also influenced by the growth rate of urban development like the economic activity hubs and the urban infrastructure has a prompt impact on the configuration.

Third, the lead-lag effect between Seoul spatial configuration and economic factors were analyzed by time series test and geographically weighted regression analysis. Time lag was quantified. When the change of the spatial configuration hubs was rapid from 1970 to 1990, there was 10-year time lag between the spatial configuration and economic factors. In the meantime, when the change of the spatial configuration hubs was slow from 1990 to 2000, there was little time-lag. Therefore, it is known that there exists lead-lag effect between spatial configuration and economic factors and time lag happens when the speed of urban change is rapid. It means that the spatial configuration almost coincides with the establishment of infrastructure by urban development, affecting the economic activity throughout time passage. In addition, it was known that the economic factors can be affected by the potentiality of the previous configuration even after the cause of urban development (e.g. Kangnam development) stops.

The studies regarding urban space structure such as Kim(2009) and Kim(2002) examine the timing of occurrence by correlation analysis between spatial configuration and social and economic factors. This study is mean in comparison with the preview studies in identifying the lead-lag effect between spatial configuration and economic factors and could suggest that the change of economic factors follows spatial configuration. If future studies attempt to study on spatial configuration in future, based on these findings, they (the findings) will help them predict the timing of economic factor change. This study suggests implications to be used in setting urban planning and policy guideline in confidence at the lead-lag effect. In addition, the changing forecast of economic activity will be useful on each period prediction of energy demand with existing research.

This study analyzed the lead-lag effect of spatial configuration and economic factors during

1970s through 2010s. It has limitation in that it used only 4 stages of the changes over 40 years. In addition, it used only employment density as economic factor, despite a variety of the factors such as induced traffic volume, office size and so on. Following study needs to include more diverse economic factors to more systematically predict the timing of economic factor change related to urban development.

Acknowledgement

This research was supported by a grant(code 11High-techUrbanG05) from High-tech Urban Development Program (HUDP) funded by Ministry of Land, Transport and Maritime Affairs of Korean government.

References

Bourne, L. S. 1991. “The Roepke Lecture in Economic Geography Recycling Urban Systems and Metropolitan.” *Economic Geography* 67: 185-209.

Herbst, Anthony F., Joseph P. McCormack, and Elizabeth N. West. 1987. “Investigation of a lead-lag relationship between spot stock indices and their futures contracts.” *Journal of Futures Markets* 7: 373-381.

Hou, Kewei. 2007. “Industry Information Diffusion and the Lead-lag Effect in Stock Returns.” *Oxford Journals* 20: 1113-1138.

Brunsdon, C., S. Fotheringham, and M. Charlton. 1998. “Geographically weighted regression.” *Journal of the Royal Statistical Society* 47: 431-443, September.

Green, David L. January, 1980. “Recent Trends in Urban Spatial Structure.” *Growth and Change* 11: 29-40.

Kim, Changsuk. 2000. “The Hierarchy of Centers and Their Characteristics in Seoul.” The Journal of Korea Planners Association 35: 17-29.

Cho, Jaesung. 1995. “Urban Change and Urban Planning in Seoul.” *The Journal of Korea Center for city and environment research* 1: 241-255.

Song, Mireung. August, 1997. “The Spatial Structure of Seoul: changes and Characteristics.” *The Journal of Korea Planners Association* 90: 209-228.

Bourne, L. S. 1982. *Internal structure of The City.* Oxford University Press, New York.

Hillier, Bill, and Julienne Hanson. 1984. *The social logic of space.* Cambridge University Press.

Kim, Kwangjoong et al. 2001. *The Spatial History of Seoul in the 20th Century.* Seoul Development Institute.

Kim, Kiho et al. 2012*. The Management General Plan of Historic Cultural City for Seoul 4 Major Gates.* Seoul Metropolitan Government Press.

Kazuhiro, O. et al. 2009. *Urban Economy and Reindustrialization.* Translated by J. M. Na. Hanwool Academy Press.

Lee, Youngsuk, Yooki Kim, and Beckyoung Kim. 2011. “City is History.*” In Seoul*, 14-37. West Sea Publisher Press.

Kim, In. 1991*. Principle of Urban Geography.* Bobmunsa Publisher Press.

Park, Junghee et al. 2011. *100 Years of Modern History of Youngdungpo.* Youngdungpo-gu office

Press.

Kim, Sunwoong. 1998. *An Analysis of the Change of Seoul Centers and Policy Task.* Seoul development institute Press.

Kim, Junghee. 2009. “A study on changing Urban Spatial Structure of Seoul by GIS and Space Syntax: 1970’s~2000’s.” PhD diss., University of Korea.

Sun, Kwansoo. 2009. “The Characteristics of Urban Spatial Structure and Urban Center System: In the Case of the Seoul Metropolitan Area.” Master diss., University of Hanyang.

Kim, Haena. 2001. “A study on the relationship between residential distribution of eminent persons and change of spatial structure in Seoul.” Master diss., University of Hanyang.

Jeon, Junwoo. 2001. “A Study on the Changes of Seoul City's Urban Spatial Structure.” Master diss., University of Hanyang.

Seo, Nakyoung. 2008. “A Study of the Commercial Area Analysis.” Master diss., University of Kwangwoon.

Ahn, Jinhyoung. 2009. “A Study on Space of Assembly and Culture Linked with the Surface Design of Architecture.” Master diss., University of Hongik.

Kim, Sangwoo. 2010. “A Study on the Plan to Activate Quasi-Industrial Areas by Spatial Division.” Master diss., University of Hanyang.

Son, Dongook, Hongku Kim, Youngook Kim, and Wan Yoo. 2001. “Analysis of the relationship between land-use density of Office buildings and urban street configuration.” Paper presented at the annual meeting for The Korea Planners Association, Kyoungju, Republic of Korea, November 3.

Wikipedia. 2013. “Guro-District.” Last modified May 20, 2013. Http://ko.wikipedia.org/wiki/Guro_District,_Seoul.