

Crime Trend Analysis by Changes of Spatial Autocorrelation and Hot-spot

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Abstract—To prevent crimes, understanding the space structure of society is very important because crime is a serious social problem. This research analyzes SA and LISA which is the spatial autocorrelation analysis, and they are considered the factor of space based on the five major crime occurrence data of Seoul from 2011 to 2013. The result could identify the spatial dependence and figure out the hot-spot, cold-spot and special outlier. This research shows the flow of result by year interpreted from the result of LISA with group number, type of crime and area. First, group number standard is that the number of hot-spot and cold-spot decreased and spatial dependence decreased either. Second, type of crime could find meaningful characteristics in theft, murder and robbery. Third, area pattern is that Songpa-gu showed hot-spot and Nowon-gu showed cold-spot for three years. Also, Seocho-gu showed hot-spot and LH and we could know that the crime rate decreased. Dongjak-gu and Yangcheon-gu mostly showed LH and this means that the crime rate decreased. This result can be used to prevent crimes which are centering hot-spot areas and considering the spatial dependence.

Keywords— *Crime incidence; Spatial dependence; Five major crime; Hot-spot; Moran's I*

I. INTRODUCTION

Now Korea's crime shows the increasing tendency and it has become a serious problem. Social interest of crime, prevention and control are piling up because of this [1, 2]. Analyzing the cause of crime is more important than other elements to prevent and control the crime. Meanwhile, cause analysis on crime is defined as sociologic, biological, and psychological viewpoint and so on. However, crime is not a personal problem, so studying construction of space of society is needed. Districts where crime had occurred socially cause a lot of effects to other places [3]. Also, people move to residential areas because of social reasons and gather in particular districts which have similar characters. Because this result was collected from administrative district, studying considering spatial factors such as a district must be conducted [4].

There are many ways to analyze the causes of crime, considering the spatial factors. It is possible to analyze by figuring out the distribution at large, analyzing presence of spatial dependence, finding spatial gathering and exploring the influential factors of crime. The most important one is to figure out the presence of spatial dependence. Other researches can be meaningless if spatial dependence exists. Therefore, when spatial interaction influences negatively as analysis result of spatial dependence, it can prevent crime by finding the way to decrease the interaction. Through this, finding out the spatial dependence can contribute to crime prevention.

This paper will show three purposes. First purpose is to find space effects of crime which appear in research areas through spatial autocorrelation analysis. Spatial autocorrelation is analyzed as a global aspect and this can be used to investigate the spatial dependence of research areas. Second, finding hot-spot, cold-spot and special outliers of research area using LISA(Local Indicator of Spatial Association) is the second purpose. This can be found through presenting spatial grasp as visual form in a local aspect. Searching an aspect of transition through analysis of a global and local aspect is the last. Search changes of spatial dependence by crime types through a global aspect and analyze hot-spot, cold-spot and increase, decrease and changes of area of distribution through special outliers.

This research sets the research area to Seoul city, Korea because the city has many examples due to the high number of crime generation, and is likely to happen actively correlation among areas for the highest mobility of population and large number of population. For the specific research method, first, convert the number of five major crimes of Seoul, 25 districts and crime number per population to the form that is suitable to spatial statistic frame. This based on data of crime number investigation of Seoul from 2012 through 2014 crime analysis which supreme prosecutors' office had investigated. Second, interpret the crime number by number of police substation and find spatial dependence, hot-spot, cold-spot and special outliers per crime type base on 1:1000 digital cadastral map of Seoul by GeoDa[5] which is a space statistical analysis program. Third, find out an aspect of transition based on the analyzed result. Through this, discover the changes of spatial dependence per

crime type pursuant year in a global aspect and grasping the feature of hot-spot, cold-spot and special outliers with number, area and crime type standard.

II. BACKGROUND

A. Crime and space statistical analysis

Researches which analyzed crime space by using spatial statistics technique [4, 6, 7, 8, 9, 10, 11, 12] approached the viewpoint that analyzing the crime patterns, finding hot-spot and investigating the main cause that effect to crime occurrence. This research searched existing research case that centrally analyzed space dependability. First, examined the research that analyzed with global and local aspect through construe the crime data with point feature and side feature for grasp the spatial pattern. [6] aimed for seven major crimes that had occurred in partial area of Gangnam-gu, Seoul for 4 years. Constructed side feature data per areal unit that consolidated by road and used inverse distance matrix for spatial weight matrix. Based on this, deducted the Moran's I stat that analyzing the spatial autocorrelation and with the result that could identify the spatial dependence from total crime number. Also, unearthed that assault, theft, rape and robbery had positive auto-correlation and murder, arson and drug has negative auto-correlation. [7] collected a two-years arrest number with city and district level to grasp the space pattern of teenagers prostitution in capital area. Showed total number of offenses and number of offenses per hundred thousand people by quartile map and showed result of LISA by Cluster map. The result of measurement of Moran's I index showed positive spatial autocorrelation. But did not mention about process of defining the spatial proximity and chosen spatial weight matrix.

Next, examined the research that apply the spatial regression model to determine the main cause that influence to crime occurrence after analyzed the spatial pattern like other researches. [8] progressed the research orient Seongbuk-gu, Seoul. Counted polygon features per Dong, accomplished spatial autocorrelation analysis and forged the spatial weight matrix as neighbor among regions that within 1,600m. [9] analyzed time period. It showed that spatial autocorrelation exist and rape of Masan city had negative autocorrelation unlike other types of crime. Also found the hot-spot and cold-spot of polygon feature through LISA. When it choose the Rook, deducted optimal value. [10] suggested partial crime analysis model and accomplished space time test statistic that considered time to establish the influencing relationship between construction of space and city crime. Accomplished SA and LISA to examine the group tendency in polygon features. The result that deduct Moran's I and Local Moran's I by using the Rook and the Queen was that five major crime per population of Changwon city had spatial dependence, rate of assault, murder and robbery showed negative spatial autocorrelation that shows diffuse distribution through interaction between spaces and total crime rate, theft, rape shows positive spatial autocorrelation that forming group through interaction between spaces. Masan city showed negative has spatial dependence in all types of crime and rape crime rate shows spatial autocorrelation. [11] conducted LISA and applied Local Moran's I based on the polygon features data that divided research area into 60 blocks. But did not explain the way that defining the spatial proximity. [4] accomplished crime pattern analysis and spatial regression to establish the location of CPTED(Crime Prevention Through Environmental Design) facilities. Established Dongan-gu, Anyang city, Gyunggi-do and collected polygon feature data by Dong. Choose the Rook for spatial weight matrix that stable normal distribution form by comparing the weight matrix histogram by the Rook and the Distance. Used Moran's I for spatial autocorrelation analysis. And showed two-dimensional analysis result by Moran's I scatter diagram that put CCTV as stat per prime variable and subordination variable and put each variable as explanatory variable. Used Local Moran's I in local aspect and showed it by Cluster map.

Unlike aforementioned research, [12] progress research around spatial dependence. Progress oriented national and collected five major crime data cities and district level from 2000 to 2010. Applied adjacency matrix, inverse distance matrix and inverse distance square matrix and interpreted it centrally inverse distance matrix which has high significance. Showed crime occurrence and crime occurrence per hundred thousand people through quartile map and analyzed space dependability of national in flank of global and local by using Moran's I. The result was that crime occurrence in flank of global was analyzed by each type of crime of five major crimes and total crime had spatial dependence.

The result that examined the existing researches on analyzed space pattern of crime stand on the basis space statistical analysis is that should identify the being of spatial autocorrelation to establish the right regression model before progress the regression analysis besides grasped the dependence between crime areas. Used Moran's I for tool of spatial autocorrelation analysis and did not have particular spatial weight matrix that had used many times. So, it is needed to show the progress of choosing spatial weight matrix and needed to choose the way that has high dependence after analyze by using more than two spatial weight matrixes.

III. RESEARCH METHODOLOGY

A. Spatial analysis

Spatial data includes not only figure information but also spatial information. To analyze spatial data by existing linear model, it does not reflect characteristics of space and could overlook Tobler(1970)'s the first law of geography. He suggested

spatial dependence and spatial interaction as characteristics of space. For an alternative way to do it, spatial autocorrelation analysis received attention.

Spatial Autocorrelation is a similar tendency between one area and its surrounding areas. If data tends to show similarity and forms an assemblage, then positive spatial autocorrelation appeared. On the contrary, If data tends to show difference, negative spatial autocorrelation would appear.

There are Moran's I and Greary's C as typical measuring tools of spatial autocorrelation. In this research, using Moran's I is used most extensively, and is defined as below.

$$I = \frac{n}{\sum_{i=1}^n (x_i - \bar{x})^2} \cdot \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \quad (1)$$

- n : The number of administrative district
- x_i : The number of occurrence of district i
- \bar{x} : The average value of x_i
- w_{ij} : The weight value

$\sum_{j=1}^n w_{ij}$ is the spatial weight matrix value that shows proximity of space. In accordance with ways to define spatial proximity, spatial weight matrix changes. So, It is important to find the spatial weight matrix before computing Moran's I. Spatial proximity was defined by physical adjacency or distance. When sharing a boundary line or an edge between districts, it is physically adjacency [13]. Constructing a spatial weight matrix based on physical adjacency, it is called adjacency matrix. There are three typical methods: Rook; Bishop; and Queen. The case of Rook is to share a common boundary line of two areas, the case of Bishop is to share the edge of two areas, and the case of Queen is to combine the case of Rook and the case of Bishop gives weight 1.

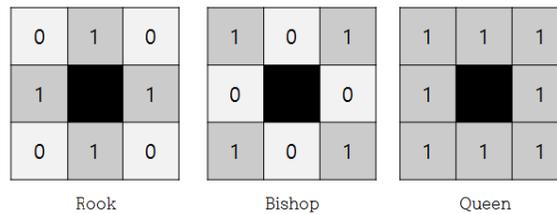


Fig. 1. Weight example through adjacent matrix definition method

Fig. 1 is the result that creates weights and shows connectivity histogram using GeoDa's tool. Histogram that represents normal distribution is appropriate [14]. As a result, Rook method is chosen among weights because of its normal distribution in this research,.

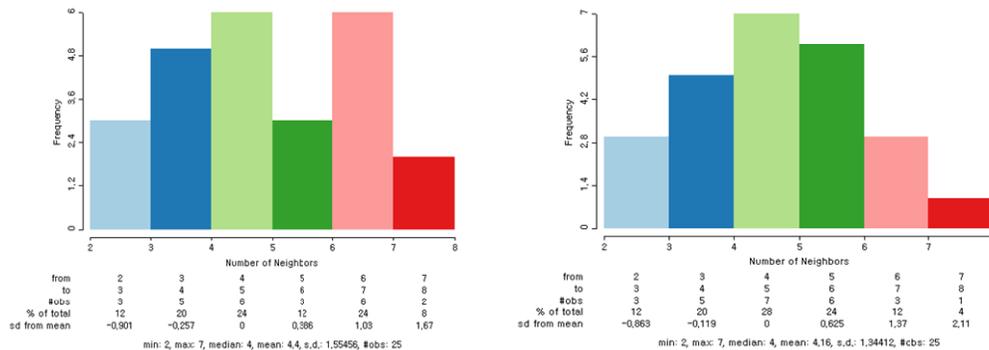


Fig. 2. Histogram per adjacency matrix way(Left-Rook, Right-Queen)

Also, Threshold distance method is used to compare with Rook method. Threshold distance set-up at least that every district has neighboring area. Histogram that shows the neighboring areas using threshold distance method is as follows, Fig. 3.

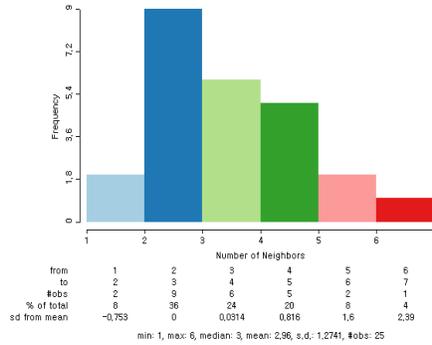


Fig. 3. Distance weight matrix histogram

Moran's I statics were defined as the scale from -1 to 1. When the statics are lower than 0, they signify negative spatial association, spatial difference. On the contrary, when they are higher than 0, they signify positive spatial association, spatial dependence.

B. Local indicator of spatial analysis

Moran's I indicates spatial autocorrelation between regions in a global level. Consequently, it is impossible to comprehend space effects in a local level. LISA is suggested as an alternative to minimize an error of SA [15]. Using of LISA can read off the degree that spatial autocorrelation of subarea contributes to one of the whole research areas and verifies significance of SA. Also, it can extract an assemblage zone and spatial outlier.

Local Moran's I was used to indicate LISA and defined as follows.

$$I_i = (x_i - \bar{x}) \sum_{j=1}^n w_{ij} (x_j - \bar{x}) \tag{2}$$

w_{ij} : The weight value

Spatial autocorrelation is classified as four types: HH(High-High), LL(Low-Low), HL(High-Low), LH(Low-High) through the scatter of Moran [14]. HH correspond to an area that has a high index and its surrounding areas too. LL is opposed to HH. In case of HH, it is an assemblage of high index, so it is called crime hot-spot. On the other hand, LL is called crime cold-spot. HL and LH are spatial outliers, which have different indexes between the area and its surrounding area.

IV. ANALYSIS RESULT

A. Crime occurrence change by district

Examined the changes of five major crime occurrence for three years from 2011 to 2013. The occurrence of five major crimes was increasing every year. The year of 2011 reveals 7,105 cases and it took 5.1% of total crimes. In 2012, there was 106,069 that 5.4% of total crimes and increased 9.2% year on year. In the case of 2013 was 106,505 that 5.3% of total crimes and increased 0.4% year on year.

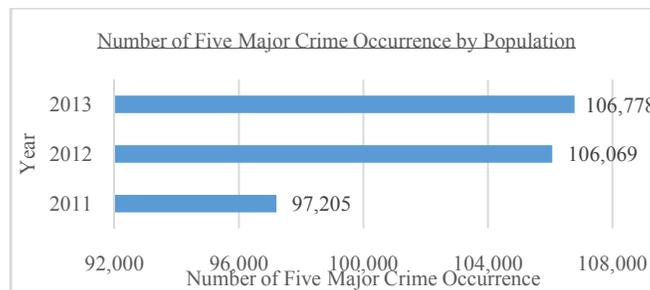


Fig. 4. Number of five major crime occurrence by population

Each type of crime occurrence was showed as following: theft is 60,464, murder was 201, robbery was 622, rape was 6,559 and assault was 35,373 averagely. Theft increased every year, murder and robbery decreased every year and rape and assault decreased and increased again.

<Table I> was the quartile map that signifies the crime occurrence and crime rate comparison of population five major crimes from 2011 to 2013. Theft and total crimes detected likewise and Gangnam-gu, Songpa-gu, Gwanak-gu and Yeongdeungpo-gu showed high tendency. The case of murder in those areas which showed high tendency in 2011 also showed high tendency in 2013. The highly crime-occurring area of robbery was similar between 2012 and 2013 and Jungnang-gu which appeared in 2012 did not appear in 2013. Quartile map from 2011 to 2013 of rape was similar and had less differences between 2012 and 2013. Assault had difference with highly crime-occurring areas but the form was similar.

Changes of crime rate per population had the case that changes form following the year change and in the other way showed similar form for three years. In the former case, murder, robbery and assault were included. Because of the extra area of each year, form of murder was different but had high group surrounding Yongsan-gu. In robbery, the surrounding of Yongsan-gu, Jung-gu and Jongno-gu showed high tendency for three years. It had difference with murder that murder had an extra area each year but could find the common that appeared around Yongsan-gu, Jung-gu and Jongno-gu. Assault appeared high incidence of crime area with Jung-gu as the center. Especially Geumcheon-gu, Jongno-gu and Jung-gu constantly showed high tendency. The latter included theft, rape and five major crimes. The case of theft, high tendency between 2011 and 2012 were same and in 2013 had difference that Seodaemun-gu was excluded and Yongsan-gu was added. Rape showed high tendency at Gangnam-gu, Seocho-gu, Jongno-gu and Jung-gu and the form was similar at large. Five major crimes steadily showed high tendency at Jung-gu, Jongno-gu, Yeongdeungpo-gu, Gangnam-gu and Gwangjin-gu. In 2012, Seodaemun-gu was added. It was the same as 2013 and had little difference in 2011.

TABLE I. CHANGES OF CRIME OCCURRENCE PER DISTRICTS

Types of crime	Crime Occurrence Standard		
	2011	2012	2013
Five Major crime			
Five major crime per population			
Theft			
Theft crime rate per population			
Murder			
Murder crime rate per population			
Robbery			
Robbery crime rate per population			
Rape			

Types of crime	Crime Occurrence Standard		
	2011	2012	2013
Rape crime rate per population			
Assault			
Assault crime rate per population			

The interpretation of this analysis result could find out the meaning with considering the variation with the number of police substations and patrol divisions. The crime number of Jongno-gu, Jung-gu, Yongsan-gu, Nowon-gu, Yangcheon-gu, Gangseo-gu, Dongjak-gu, Seocho-gu and Gangdong-gu constantly increased but the number of patrol divisions did not change. Also, crime number of gwangjin-gu, Seongbuk-gu, Seodaemun-gu and Gwanak-gu were increased but the number of police substations was decreased. Especially, the case of Seodaemun-gu, number of crime most highly increased and almost three times increased than last year between 2011 and 2012. On the other hand, the number of police substations and patrol divisions in Seongdong-gu, Dongdaemun-gu, Gangbuk-gu, Dobong-gu, Eunpyeong-gu, Mapo-gu, Guro-gu, Geumcheon-gu, Yeongdeungpo-gu, Gangnam-gu, and Songpa-gu were not changed, but the crime number were constantly increased or decreased. Also, number of police substitutions of Jungnang-gu increased every year and the number of crime increased between 2011 and 2012 but decreased in 2013.

B. Global spatial autocorrelation changes of crime occurrence

There was no standard to choose spatial weight matrix to measure spatial autocorrelation, so it would be advisable to choose another one if an error occurred. To assess and compare both Rook method and Threshold distance method. <Table II> shows three years' spatial autocorrelation using Rook method, and <Table III> shows using Threshold distance method. First, focusing on the general trend, spatial dependence of theft, murder, robbery, assault tended to decrease. However, judging from spatial autocorrelation of theft in 2011, it was possible to infer that the crime was still deeply related to social phenomenon. Murder, robbery, assault stands for very negative correlation. Especially, Moran's I of murder using Threshold distance method was -0.3115 in average and it represented the most diffuse distribution, Extraordinarily, in case of rape, its spatial dependence increased and crowded. In case of five major crimes, there was little significant measurement, but it was possible to interpret that spatial dependence existed.

TABLE II. THE ROOK MORAN'S I OF CRIME OCCURRENCE

Year	Theft	Murder	Robbery	Rape	Assault	Total
2011	0.2118*	-0.1485	0.0176	0.0400	-0.1165	0.0705
2012	0.0958	-0.1710	-0.2472*	0.0423	-0.2952**	-0.0311
2013	0.0847	-0.1543	-0.2063	0.0765	-0.2331*	-0.0139

TABLE III. THE DISTANCE MORAN'S I OF CRIME OCCURRENCE

Year	Theft	Murder	Robbery	Rape	Assault	Total
2011	0.3825**	-0.3248*	-0.0621	0.1750*	-0.0714	0.2253*
2012	0.2874**	-0.3160*	-0.3377**	0.2399*	-0.1875	0.1646
2013	0.2241*	-0.2939**	-0.2862*	0.2643**	-0.1753	0.1293

*p<0.1, **p<0.05

In <Table IV> and <Table V>, independent variable were the number of crime committed per population and showed influence of population to compare with the number of crime committed. A result using Rook method is <Table IV> and a result using Threshold distance method is <Table V>.

As spatial dependence of theft, rape, assault, five major crime rate was gradually decreased, spatial interaction that has declining tendency did not have an alteration despite standardizing population. Spatial autocorrelation of theft, rape, assault, five major crime rate represented very high degree, Above all, rape crime rate using Threshold distance had the strongest spatial dependence in average 0.5405. Although the crime rate of murder and robbery were not significant, it was possible to interpret that they formed negative spatial autocorrelation or had low spatial dependence. The number of assault crime occurrence had negative spatial autocorrelation, but considering population it had positive spatial autocorrelation.

TABLE IV. THE ROOK MORAN'S I OF CRIME RATE PER POPULATION

Year	Theft/ Population	Murder/ Population	Robbery/ Population	Rape/ Population	Assault/ Population	Total/ Population
2011	0.3270**	0.0183	-0.1373	0.2878**	0.2726**	0.3145**
2012	0.2556**	-0.0076	0.0854	0.1868*	0.2056**	0.2430**
2013	0.2971**	-0.1452	0.0568	0.2128*	0.2281**	0.2797**

TABLE V. THE DISTANCE MORAN'S I OF CRIME RATE PER POPULATION

Year	Theft/ Population	Murder/ Population	Robbery/ Population	Rape/ Population	Assault/ Population	Total/ Population
2011	0.4755**	0.0649	-0.2191*	0.5663***	0.4034**	0.4708***
2012	0.4583**	-0.0287	0.1780	0.5273***	0.4133**	0.4604***
2013	0.4522**	-0.2853*	0.1762	0.5280***	0.3842**	0.4510**

*p<0.1, **p<0.05, ***p<0.01

C. Local indicator of spatial association changes of crime occurrence

In this research, Cluster Map was shown after finding out hot-spot, cold-spot, and outlier of five major crime through LISA based on Rook method and distance weight matrix from 2011 to 2013. The credibility of analysis result was more than 95%.

According to <Table VI>, correlation of five major crimes generation number in 2011 was that hot-spot in five major crime, theft, robbery and rape and five major crimes, theft and robbery found out a high crime rate in Songpa-gu and Gwangjin-gu in common. Outside of that, hot-spot was found in Gangdong-gu for theft. The other ways of cold-spot was variously found in all type of crime. Low crime rate was built in Gangbuk-gu, Nowon-gu and Jung-gu. Gangbuk-gu was appeared in five major crimes and theft of cold-spot, Jung-gu appeared for assault and Nowon-gu appeared for theft and rape. HL of special outlier shows in five major crimes and murders. The case of five major crimes appeared at Jung-gu and murder appeared at Eunpyeong-gu. LH of special outlier was detected for murder, robbery, rape and assault. Murder appeared in Dongjak-gu and Seocho-gu, robbery appeared in Seocho-gu, rape appeared in Geumcheon-gu and Yongsan-gu and assault appeared in Geumcheon-gu.

Also, <Table VI> showed the result of LISA in case of standardized population. All types of crimes excluding five major crimes and robbery formed a high rate of incidence in Songpa-gu and the surrounding areas in common. On the other hand, Jung-gu formed a low rate of incidence with surrounding areas. Gwangjin-gu was LH that corresponding area's crime rate was low and neighboring area's crime rate was high like isolated area. In addition murder appeared hot-spot in Seocho-gu and cold-spot in Seodaemun-gu. The case of robbery that showed exceptional distribution showed HL in Gwangjin-gu which appeared as LH in other analysis and LH in Seodaemun-gu. Generally, each type of crime excluding five major crimes and robbery did not appear as HL.

TABLE VI. LISA CLUSTER MAP WITH ROOK OF 2011 FIVE MAJOR CRIME

Type of crime	Crime occurrence	Crime occurrence per population	Type of crime	Crime occurrence	Crime occurrence per population
Five major crime			Robbery		
Theft			Rape		
Murder			Assault		

The following <Table VII> showed that there were not many areas which correspond to four categories of Local Moran's I in 2012 the number of crime occurrence. In case of murder, robbery, assault, and five major crimes, outliers were detected, but there were no hot-spot or cold-spot. Murder in Dobong-gu and Gwanak-gu became HL, in Mapo-gu and Yangcheon-gu became LH. In case of robbery only Seocho-gu showed LH, assault showed HL in Yeongdeungpo-gu only and five major crimes showed HL in Seocho-gu only. Theft did not appear in special outliers, but appeared as hot-spot in Songpa-gu and cold-spot in Nowon-gu. Rape appeared as hot-spot in Seocho-gu, cold-spot in Nowon-gu and LH in Yongsan-gu.

<Table VII> arranged the types of Local Moran’s I considering population. First of all, Songpa-gu showed hot-spot in theft, robbery, rape and assault that showed hot-spot in 2011 analysis result. Similarly, Gwangjin-gu that showed LH in 2011 analysis result showed LH in five major crimes, theft, robbery and assault in 2012 analysis result and continued the flow. Outside of that Gangdong-gu showed hot-spot in five major crimes and assault and Dobong-gu showed cold-spot in murder. The case of special outlier, HL appeared at Seodaemun-gu in robbery and at Yeongdeungpo-gu in assault.

TABLE VII. LISA CLUSTER MAP WITH ROOK OF 2012 FIVE MAJOR CRIME

Type of crime	Crime occurrence	Crime occurrence per population	Type of crime	Crime occurrence	Crime occurrence per population
Five major crime			Robbery		
Theft			Rape		
Murder			Assault		

According to <Table VIII>, the interrelationship of 2013 crime generation number was not detected as last year. All types of crimes excluding rape and assault appeared in special outliers when hot-spot and cold-spot did not appear and appeared as hot-spot and cold-spot when special outlier did not appear. The case of theft Songpa-gu showed hot-spot and Nowon-gu showed cold-spot. It was the same in five major crimes. Murder showed LH in Seocho-gu and Mapo-gu, robbery showed HL in Dongdaemun-gu and LH in Seocho-gu and Dongjak-gu. The case of rape, Seocho-gu appeared as hot-spot, Nowon-gu showed cold-spot and Yongsan-gu became LH. In case of assault, showed negative autocorrelation in Moran’s I but did not show any spatial autocorrelation even hot-spot and cold-spot which was not a negative autocorrelation. Therefore, it could not interpret as meaningful result.

<Table VIII> included the result that based on the number of crimes per population. Five major crimes such as theft, robbery, rape and assault had same regional distribution that showed spatial autocorrelation. The hot-spot was Songpa-gu and cold-spot was Gwangjin-gu. Songpa-gu and Gwangjin-gu shows same regional distribution in theft. Murder doesn’t have place that shows hot-spot, cold-spot and HL type and Seocho-gu and Mapo-gu showed LH type. Also, it could not find the case that corresponding area and neighboring area had a low crime rate together in five major crimes and each type and the case that corresponding area had a high crime rate but its surrounding area had a low crime rate.

TABLE VIII. LISA CLUSTER MAP WITH ROOK OF 2013 FIVE MAJOR CRIME

Type of crime	Crime occurrence	Crime occurrence per population	Type of crime	Crime occurrence	Crime occurrence per population
Five major crime			Robbery		
Theft			Rape		
Murder			Assault		

The result of Local Moran’s I analysis with 2011 data and Distance which was spatial weight matrix was shown in Table IX. Hot-spot showed in five major crimes, theft, robbery and rape and Songpa-gu and Gangnam-gu was shown in all types as mentioned. In addition, Seocho-gu showed five major crimes and robbery. Cold-spot was shown in all types of crime except for murder and robbery. Five major crimes appeared in Nowon-gu and theft appeared in Gangbuk-gu and Nowon-gu. Nowon-gu showed a common distribution form. Besides, assault showed cold-spot in Yongsan-gu and Jung-gu. HL type was detected

in various districts like Jung-gu, Gwanak-gu, Dongjak-gu and Yongsan-gu etc. LH type appeared in Yeongdeungpo-gu and Yongsan-gu in murder and appeared in Geumcheon-gu for rape and assault.

<Table IX> includes the result of the 2011 crime occurrence number analysis that added the variable called population. Hot-spot and cold-spot appeared in a few districts. Hot-spot appeared in Songpa-gu, Gangnam-gu and Seocho-gu and cold-spot appeared in Nowon-gu, Seodaemun-gu and Yongsan-gu. Also, the LISA cluster map of theft, robbery and five major crimes had the same form that shows hot-spot that appeared in Songpa-gu and Gangnam-gu and cold-spot that appeared in Nowon-gu and Songpa-gu. Songpa-gu showed hot-spot in murder, robbery, rape and assault. The case of special outlier was that Yeongdeungpo-gu showed HL for murder and Gwangjin-gu showed LH for robbery and assault.

TABLE IX. LISA CLUSTER MAP WITH DISTANCE OF 2011 FIVE MAJOR CRIME

Type of crime	Crime occurrence	Crime occurrence per population	Type of crime	Crime occurrence	Crime occurrence per population
Five major crime			Robbery		
Theft			Rape		
Murder			Assault		

<Table X> is the result that analyzed the group pattern of 2012 crime number with Distance spatial weight matrix. Five major crimes and theft showed the similar pattern that commonly showed hot-spot in Mapo-gu, Songpa-gu and Seocho-gu and cold-spot in Nowon-gu. In addition, five major crimes showed cold-spot in Yongsan-gu and LH in Gwanak-gu. Murder and robbery only showed the special outlier. Murder showed HL in Dobong-gu and LH in Mapo-gu and Yangcheon-gu and robbery showed HL in Gangbuk-gu and Yongsan-gu and LH in Seocho-gu and Dongjak-gu. The case of rape was that the crime rate of Seocho-gu and the surrounding area is high and the crime rate of Gangbuk-gu, Nowon-gu and the neighboring area was low. Assault showed cold-spot in Yongsan-gu and LH in Seocho-gu and Mapo-gu.

Next, the result that considered population was <Table X>. All types of crime except murder and robbery had similar form of hot-spot and cold-spot and murder did not show hot-spot, but other types showed hot-spot mostly in Songpa-gu, Gangnam-gu and Seocho-gu. Especially, Songpa-gu showed hot-spot in all types except murder. The case of cold-spot was that Yongsan-gu show cold-spot in many type include murder and the otherwise appeared in Dobong-gu, Seongdong-gu and Nowon-gu. There was many type that did not appear the outlier. HL appeared in theft at Seongbuk-gu and in robbery at Seodaemun-gu. LH appeared in murder at Mapo-gu, in robbery at Seocho-gu and in assault at Gwangjin-gu.

TABLE X. LISA CLUSTER MAP WITH DISTANCE OF 2012 FIVE MAJOR CRIME

Type of crime	Crime occurrence	Crime occurrence per population	Type of crime	Crime occurrence	Crime occurrence per population
Five major crime			Robbery		
Theft			Rape		
Murder			Assault		

<Table XI> is cluster map which analyzed the LISA based on number of 2013 five major crimes with Distance spatial weight matrix. Five major crimes and theft showed hot-spot in Seocho-gu and Songpa-gu, cold-spot in Nowon-gu and LH in Mapo-gu as same as last year. In addition, theft shows hot-spot in Gangnam-gu. Murder and robbery did not form positive correlation, but showed HL in Yongsan-gu and Dongdaemun-gu and LH in Dongjak-gu. Robbery showed HL in Gwanak-gu and LH in Seocho-gu. Rape formed positive correlation, unlike murder and robbery, showed hot-spot in Seocho-gu and cold-spot in Nowon-gu. The case of assault was that showed cold-spot in Yongsan-gu and HL in Gwanak-gu and LH in Seocho-gu.

The result that considered the population was <Table XI>. Songpa-gu and Gangnam-gu showed hot-spot in all types except murder. In addition, Seocho-gu showed hot-spot for theft and robbery. The case of cold-spot was converged in few districts. Mostly appeared in Nowon-gu and five major crime and assault showed cold-spot in Seongdong-gu and robbery appeared at Yongsan-gu. Special outlier appeared as HL in Yongsan-gu and Seodaemun-gu for murder, Dongdaemun-gu showed HL for murder and robbery and Mapo-gu showed LH in Mapo-gu for murder.

TABLE XI. LISA CLUSTER MAP WITH DISTANCE OF 2013 FIVE MAJOR CRIME

Type of crime	Crime occurrence	Crime occurrence per population	Type of crime	Crime occurrence	Crime occurrence per population
Five major crime			Robbery		
Theft			Rape		
Murder			Assault		

V. DISCUSSION AND PROPOSAL

This research interpreted the group number, type of crime and area based on the analysis result of LISA with Distance spatial weight matrix. First, it analyzed the flow of hot-spot, cold-spot, HL and LH changes. The number of hot-spot decreased as 8 in 2011, 7 in 2012 and 6 in 2013. The number of cold-spot also showed decreasing tendency. HL decreased as 8 to 6 from 2011 to 2013. LH increased 5 to 6. The decreasing tendency of hot-spot and cold-spot mean that the area which showed positive correlation decrease.

The group number case was extended, considering the population showed that the tendency of hot-spot was different. Cold-spot was increased from 2011 to 2012, but decreased from 2012 to 2013. HL showed similar tendency between numbers of crime occurrence standard. LH decreased as 3 in 2012 to 1 in 2013.

The type of crime pattern which examined the spatial dependence tendency of each types of crime for three years was that hot-spot detected at Songpa-gu and cold-spot detected at Nowon-gu for three years. Hot-spot of theft mostly appeared in southeast and cold-spot mostly appeared in north. Murder did not show hot-spot or cold-spot and only showed special outlier. The moving tendency of special outlier of murder was that usually gathered in northwest in 2011, moved to center in 2012 and moved to southwest in 2013. Robbery showed hot-spot in 2011 but did not appear in 2012 and 2013 and only showed special outlier. Robbery had tendency that detected the spatial autocorrelation in south area like Seocho-gu and Yongsan-gu.

The types of crime which standardized the population showed hot-spot in five major crimes at Songpa-gu and Gangnam-gu. Five major crimes had high probability of crime occurrence south area. This showed the same distribution in all types of crime except murder and robbery. Especially, hot-spot of theft showed stability pattern after Gangnam-gu, Songpa-gu and Gangdong-gu was added. Generally theft was consistently low at Nowon-gu and LH type was not shown. Murder did not show hot-spot after 2011 and Yongsan-gu shows HL which showed cold-spot in 2011 and 2012 and this means that the crime rate increased. After 2012 Seodaemun-gu showed HL and Mapo-gu showed LH. Through this, the spatial autocorrelation was formed the changes when it passed from 2011 to 2012. Also, Seodaemun-gu was changed from cold-spot in 2011 to HL type and this means that the crime rate of neighboring area did not changed but the crime rate of corresponding area increase. Robbery grasped the group of low crime rate after 2012 at Yongsan-gu. Rape showed stable cold-spot at Nowon-gu and special outlier did not appeared. Lastly, the spatial dependence of assault located in core as cold-spot and showed enlargement aspect from Yongsan-gu to Seongdong-gu which were surrounding areas of Yongsan-gu. HL type did not appear and Gwangjin-gu appeared as LH in 2011 and 2012.

The area pattern was concentrated in the case of area which kept shows special type among hot-spot, cold-spot, HL and LH. Songpa-gu and surrounding area grasped the group because they had high crime occurrence in theft and rape for three years. Seocho-gu showed hot-spot in five major crimes and rape every year and this means Seocho-gu and neighboring area were high but Seocho-gu showed LH in robbery and assault and this means that Seocho-gu had low crime rate but neighboring was high. Dongjak-gu showed isolated form and appeared as LH in murder in 2011, in robbery in 2012 and in murder and robbery in 2013. Yangcheon-gu was relevant in LH which was a low type even though Yangcheon-gu was surrounded by the areas which had high murder crime occurrence in 2011 and 2012. Nowon-gu was analyzed as cold-spot in theft and robbery for three years. In other words, Nowon-gu grasped the low group because the corresponding area and neighboring area were all low. Yongsan-gu showed as cold-spot in assault for three years. The district which did not grasp the group was Gwangjin-gu, Jungnang-gu, Seongbuk-gu, Eunpyeong-gu, Seodaemun-gu, Gangseo-gu, Guro-gu, Geumcheon-gu and Gangdong-gu.

The area pattern with population effect was that first, Gangdong-gu grasped the high crime rate group. Especially, theft showed that tendency. Songpa-gu and Gangnam-gu grasped high crime rate group. Seocho-gu showed high group in murder in 2011, rape in 2012 and robbery in 2013. Also, Seocho-gu showed isolated form with LH type. This could be guess that the crime rate of murder or rape changed from LH type followed aspect of transition of robbery. LH appeared in 2011 and 2012 murder as relation of surrounding areas of Mapo-gu. Therefore, the relation showed negative autocorrelation and danger area that could change the type to hot-spot. Seodaemun-gu showed cold-spot in 2011 in murder but changed to HL in 2013. The crime rate of Seodaemun-gu was increasing and had increasing probability of crime rate of neighboring area because Seodaemun-gu briskly had spatial interaction with neighboring area. Nowon-gu showed cold-spot in many analysis like theft of rape from 2011 to 2013. Dongdaemun-gu showed LH which showed isolated form and appeared as negative spatial correlation as Mapo-gu. Gwangjin-gu showed LH and appeared as negative spatial correlation. Seongdong-gu appeared as cold-spot and this means that briskly did spatial interaction and grasped the low crime rate group. Yongsan-gu grasped low crime rate group in principle from 2011 to 2013 but murder changed to LH in 2013. This means that other types could change to LH. Jung-gu, Dongdaemun-gu, Jungnang-gu, Gangbuk-gu, Eunpyeong-gu, Yangcheon-gu, Gangseo-gu, Guro-gu, Geumcheon-gu, Dongjak-gu and Gwanak-gu did not grasp the group as the result of spatial interaction and the outlying area of Seoul that placed at Southwest could not grasp the exchanged influence between neighboring area. The area which could not find the spatial pattern mutually in number of crime and number of crime per population was Jongno-gu, Eunpyeong-gu, Gangseo-gu, Guro-gu and Geumcheon-gu.

Crime which was a social phenomenon needs to be seen with spatial viewpoint and needs the analysis that considered the effect of space. This research examined the criminology theory that studied with spatial viewpoint and research cases that analyzed crime through spatial statistics techniques. Based on this result, this research analyzed the number of crime, spatial dependence and aspect of transition of spatial group. The result, implication and hereafter research was as following below.

First, the change in the number of crime is shown on a year-on-year basis. The burglary is being annually increased among five major crimes while the number of murder and robbery is being decreased. In comparison with the change in the number of police stations and patrol divisions and the number of crime, the number of police stations and patrol divisions decreased in three districts including Gwangjin-gu but the number of crime increased. In addition, the number of police stations and patrol divisions remained but the number of crime are increased. As police stations and patrol divisions acted as a protective ability, the protective ability is likely to become absent in case of decreasing the number of police stations and patrol divisions. The correlation between two of them will be revealed through the future research. It is necessary to prevent crimes by enhancing a protective ability by means of deploying more police stations and patrol divisions in three districts including Gwangjin-gu and eight districts including Jongno-gu. In comparison with crime rates as a percentage of population, the high-ranked areas of crime rates per population were distributed in the central areas of Seoul while the high-ranked areas of the number of crime rates were distributed in the areas apart from the central areas of Seoul. Through the difference between two results from the number of crimes and the crime rates per population, the influence of population can be excluded. For example, the high-ranked areas for the third consecutive year, such as Songpa-gu, Gwanak-gu, Gangseo-gu, and Jungnang-gu were not the high-ranked areas by population's standard. It means that more crimes occurred in proportion to the number of population in three districts including Songpa-gu. Meanwhile, it was shown that more crimes occurred by factors not by the number of populations.

Second, all types of crimes are spatially influenced each other according to the spatial autocorrelation analysis. As a result, crime prevention activities need to effect based on the dependence among districts. Also, the trend of the spatial autocorrelation was figured out after analysing the three-year change of the spatial autocorrelation. Total spatial autocorrelation was decreased, but the spatial autocorrelation of rape crime is unexpectedly increasing. According to Kim (2013), the decrease in spatial dependence of rape crime was caused by the significant increase in the number of rape crime for the past decade. The number of burglary is steadily increasing, but the spatial dependence decreased. The number of rape crime decreased, which means the spatial dependence is increasing in spite of its stability. Therefore, the increase of rape crime is not correlated with the increase of the spatial dependence, so more study to find the exact background is needed. This research shows the spatial autocorrelation excluding the influence of population in comparison with the analysis result of crime rates per population.

Third, hot-spot, cold-spot, and exceptional areas were searched through the analysis of regional autocorrelation. Based on the result from the analysis, it was evaluated by the number of Local Moran's I type, crime types, and districts. On the basis of the number of Local Moran's I type, this research figures out how the spatial interaction has been macroscopically changing as years go. On the basis of crime type, the case which has an identical Moran's I cluster map between crime types and intensively distributed districts were figured out. Analysis by districts which can be the most useful indicator to prevent crimes became a criterion to decide which types, such as HH, LL, HL, and LH, are in the administrative districts. As a result, this research figured out not only administrative district belongs to the specific type but also the trend as years change. As one of the examples, Yongsan-gu normally belongs to LL type, but its murder crime rate belongs to LH in 2013. Since the change from LL type to LH can occur in other crime rates, the background of a murder crime rate change should be known. Furthermore, more effective crime prevention will be expected if the interaction among areas having high crime rate was controlled and the change from LL type and HL type is prevented.

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