IJABER, Vol. 14, No. 5, (2016): 2893-2911

THE EFFECTS OF U-CITY SECURITY SERVICE ON CRIME RATES

Hyewon Kim[*], Kabsung Kim[**] and Joohyun Lee[***]

Abstract: *The national economy of South Korea has grown exponentially after 1960s, resulting in the urbanization rate to soar 39.1% in 1960 to 91.5% in 2013. However, unlike the rapid quantitative growth, a slow trend in qualitative growth of cities has resulted in a number of urban problems, especially in crime. A number of recent studies have focused on the factors influencing crime rates, the spatial effects of crime, as well as cities operating Ubiquitous Security service for the purpose of crime prevention. This study aims to address the effects of Ubiquitous city (U-city) on crime rates within the metropolitan area of Seoul. The study first analyzes the geographical distribution of crime rates and then identifies the existence of spatial autocorrelation of crime rates within Seoul. Finally, the study determines whether the execution of U-Security service affects crime rates and other urban characteristics that influence crime rates. These effects are determined by applying spatial regression models, which can control the spatial effects and other effects of other urban characteristics on crime rates. The results of this analysis show that U-City security service does not have a statistically significant effect on crime rates. The study can be used to support the application of U-City security service to regions with high crime rates, and to address the needs of future studies that aim to compare crime rates before and after the application of U-City security service.*

Keywords: *Crime rates, Spatial Crime Pattern, Spatial Regression Model, U-city, Ubiquitous City*

I. INTRODUCTION

South Korea has experienced a rapid process of industrialization and urbanization since the 1960s. Accordingly, a number of South Korean cities, including the capital, Seoul, have accomplished a fast quantitative growth. The concentration of the population in urban areas has also grown considerably. The urbanization rate of South Korea based on the proportion of urban population to total population

[*] Department of Urban Engineering, Yonsei University, Seoul, Korea as a master student, *E-mail: kimhw210@gmail.com*

[**] University of Pennsylvania, PA USA. He is currently a professor of the Department of Urban Engineering, Yonsei University, Seoul, Korea

[***] Lee is a master student of the Department of Urban Engineering, Yonsei University, Seoul, Korea.

This work is financially supported by Korea Minister of Ministry of Land, Infrastructure and Transport(MOLIT) as 0U-City Master and Doctor Course Grant Program

increased from 39.1% in 1960 to 90.1% in 2005 to 91.7% in 2014[27] along with economic growth. However, qualitative growth of cities in South Korea has lagged behind quantitative growth, thereby resulting in various urban problems. Specifically, increasing crime rate is one of the country's most serious urban problems . The total number of crimes in Korea increased from 1,147,752 cases in 1990 to 1,933,835 cases in 2014, recording 3,768.0 crime incidences per 10 million population [31]. Violent crime cases, including robbery, rape, sexual abuse, and indecent assault, increased by 10.0% over the past five years [23].

Studies on either the influencing or preventable factors of crime have focused traditionally on judicial and social factors, and personal characteristics of victims or offenders [9][22][32]. Crimes that take place at a specific location, however, are closely associated with spatial characteristics, such as location and urban characteristics. However, few studies in South Korea [17][22] [24][33] have examined the extent to which the number of crime cases is attributed to urban characteristics [13].

Since the late 1970s, the Chicago School has begun studying crime in relation to spatial dimensions. These studies analyzed the effects of the interaction between people and urban spatial structure on crime with emphasis on the physical and social characteristics of a crime location, under the assumption that crime implies spatial and geographical characteristics [2][3] [11]. They proved that crime has a close relationship with the urban environment [28].

The number of cities that have introduced Ubiquitous city (U-city) security service, installed intelligent CCTVs for security, and operate with an integrated control center and crime prevention system is increasing [4][15].

In this context, this study aims to examine the spatial distribution of crime rates and to explore the effects of U-city security service on crime rates and the controlling urban characteristics, including demographic variables, socioeconomic variables, physical variables, defense mechanism variables, and U-City security service variable.

II. THEORETICAL BACKGROUND

(A) Theoretical Background for the Crime Factors

Traditionally, earlier studies on crime factors are based on personal characteristics inherent in human nature. These studies explored the biological and psychological characteristics of offenders. The hypothesis that crime is influenced by social structural factors or urban characteristics is a recent view that arose after major theories such as social disorganization theory, routine activity theory, and environmental criminology emerged [20].

Social disorganization theory was proposed by the Chicago School in the 1920s. Shaw and Mckay[30] argued that crime rates are not only influenced by individual properties, but also by the spatial and social characteristics of the city. They were able to identify that crime rates in the low-income residential area of city center were higher than those in the high-income residential area. The studies of Shaw and Mckay served as a foundation upon which numerous studies on the social and spatial factors that influence crime incidences are anchored [28].

Studies on the effects of urban characteristics on crime factors in South Korea began in the late 2000s. Most of these studies analyzed the causal relationship between crime incidence and crime factors by integrating environmental criminology or geography informatics with spatial econometrics analysis [10]. Studies conducted in this context generally considered demographic factors, socioeconomic factors, and physical characteristics of each region as factors that affect crime rates.

The current study considered the urban characteristics mentioned in previous studies in analyzing the effect of U-City security service on crime rates.

(B) Literature Review on Urban Characteristics as crime factors

This literature review covers previous studies that contain spatial range of South Korea because they take into account the ethnic, social, and spatial structures indigenous to Korea.

Previous studies on the association between the effects of urban characteristics and crime factors in South Korea have focused largely on two tasks. The first task is to identify hot or cold spot areas where crime rates are intensively high or significantly low. The other task is to analyze variables that influence crime incidence and the effects of those variables on crime incidence or prevention [13].

Hot spot analysis, which was introduced by Brantingham and Brantingham in1982 [18], has been used in a considerable number of criminology studies that utilized various research methods, including studying the distributions and patterns of crime incidences using spatial econometrics or GIS. However, the result of hot spot analysis depends considerably on the research purpose or analysis method, which limits the reliability of the study [13][28]. Existing studies only deal with spatial dependence and thus, also lack data that could explain a hot spot area is affected more often by crime factors. Thus, many studies adopted hot spot analysis together with multiple regression model.

The following studies estimated various multiple regression models using the same spatial range of Seoul.

Yang (2010)[33] examined the effects of crime factors on crime rates using the spatial regression model, Spatial Auto Regression (SAR), and Spatial Error Model

Table 1
Summary of Previous Studies

Researchers	*Model*	*Type of Variables*	*Name of Variables*
Lee (2015)[9]	Pooled OLS, Fixed-Effects model, Random Effect model	Dependent variables	Violent crime cases
		Explanatory variables	The number of CCTVs, children, the elderly, divorce cases, cars, apartments, commercial area ratio, industrial area ratio and green area ratio
Oh (2011)[14]	Spatial Regression model	Dependent variables	Violent crime cases per 1000 population
		Explanatory variables	Population density, flow population, amount of property tax, number of entertainment establishments, number of parking lots, park density, industrial area ratio, and commercial area ratio
Yang (2010)[8]	Spatial Regression model	Dependent variables	Violent crime cases per 10,000 population
		Explanatory variables	Flow population, college graduate ratio, police men per population, the recipient of national basic livelihood ratio, park area ratio
Lee (2010)[26]	Regression model	Dependent variables	Violent crime cases
		Explanatory variables	Population density, the number of the elderly, number of foreigners, amount of property taxes and the number of entertainment establishments
Jung (2010)[10]	Correlation, Regression model, Spatial Regression model	Dependent variables	Violent crime cases per 1000 population
		Explanatory variables	Population per household, recipient of national basic livelihood ratio, residential area ratio, number of wholesale and retails, number of accommodations and restaurants and number of police men
Jung (2008)[18]	Spatial Regression model	Dependent variables	Violent crime cases per 100 population
		Explanatory variables	Youth ratio, population density, rate of population growth, recipient of national basic livelihood ratio, level of mixed land use, ratio of apartments, ratio of old housing, the number of entertainment establishments and park area ratio

(SEM). The setting for the study was 31 police jurisdictions in Seoul, South Korea. He set 13 explanatory variables categorized as demographic, socioeconomic, and urban characteristic factors, and chose violent crime rates as dependent variable. The study concluded that demographic factors, including variables such as population density, flow population, and ratio of youths, are highly associated with violent crime rates. The recipients of basic livelihood ratio as a socioeconomic variable and the ratio of park area as a factor of urban characteristics also indicated high association with violent crime rates.

Oh (2011)[28] sought to reveal the effects of urban characteristics as categorized by demographic, socioeconomic, and physical characteristics on the violent crime rates in Seoul by using spatial regression models. In each of the 31 police jurisdictions, the study determined the effects of these characteristics on five types of violent crime per 1,000 people in Seoul. Among demographic variables, flow population affected all types of violent crimes, while population density influenced only robbery, theft, and violence. The amount of property taxes, recipients of the national basic living ratio as socioeconomic characteristics, and the number of entertainment establishments displayed a physical characteristics exhibited a significant effect on violent crime rates. Nevertheless, the study has not looked at the urban pattern.

Jung (2008)[16] concluded that urban characteristics are of great importance in preventing crime by utilizing spatial regression models (SEM and SAR). His study revealed that the ratio of youths, population growth rate, and population density, among other demographic variables, have positive (+), positive (+), and negative (-) relationship with crime rates, respectively. The recipients of national basic livelihood ratio and the average of property taxes as socioeconomic variables are associated with crime rates. Building density, the ratio of old houses, the ratio of buildings for accommodations, the number of entertainment establishments, the level of mixed land use, apartment area ratio, and park area also have affect crime rates as physical variables.

Apart from these studies, Table 1 shows the summarization of recent studies on crime factors in South Korea. Most studies used multiple and spatial regression models to analyze the effects of factors on crime rates. The dependent variable in most studies was the five major types of crime rates. These studies divided explanatory variables into four categories: demographic, socioeconomic, physical, and defense mechanism variables. However, the results of each study on the effects of the independent variables on dependent variables were not identical, and instead varied with the paper. Therefore, the current study will select explanatory variables that have been proven to affect crime rates in more than three of previous studies.

(C) Literature Review on the effect of U-City Security Service on crime rates

Few studies have attempted to investigate the association between U-City security service and crime rates, although the Ubiquitous City Comprehensive Plan

considers it a major initiative. Jeong and Park (2005)[30] reviewed research literature on U-City and discussed methods for promoting U-City security service for crime prevention in urban areas in the future. However, their study is more of a mere theoretical consideration. Choi and Hwang (2014)[4] analyzed the effect of U-City security service on the satisfaction of citizens. Studies on the effects of U-City security service on crime rates in Seoul because the security service has begun operations.

III. RESEARCH MODEL AND ANALYSIS METHOD

(A) Research Scope and the Unit of Analysis

The temporal scope of this study is set to 2012, which is the most recent time to obtain data. The spatial range is set to the Seoul metropolitan area, where 48.1% of total crime cases occur and where half of population lives in 2014. Studies on crime factors within the Seoul metropolitan area are needed because six of the top 10 areas that has the highest violent crime outbreak per population in 2012 in the country is located in the Seoul metropolitan area. Also, most areas applying U-City security service area are within Seoul metropolitan area. Therefore, the current study aims to examine the impact of U-City security service in the Seoul metropolitan area.

The current study divides the Seoul metropolitan area into 62 regions depending on the police jurisdiction and the administrative division (sigungu), and uses each as the unit of analysis.

Table 2
Unit of Analysis

Area		*Regions*
Seoul Metro-politan Area(62)	Seoul (24)	Jongno-gu, Jung-gu, Yongsan-gu, Seongdong-gu, Gwangjin-gu, Dongdaemun-gu, Jungnang-gu, Seongbuk-gu, Gangbuk-gu, Dobong-gu, Nowon-gu, Eunpyeong-gu, Seodaemun-gu, Mapo-gu, Yangcheon-gu, Gangseo-gu, Guro-gu, Geumcheon-gu and Gwanak-gu, Yeongduengpo-gu, Dongjak-gu, Seocho-gu, Gangnam-gu, Songpa-gu, Gangdong-gu
	Incheon (8)	Jung-gu, Dong-gu, Ongjin-gun, Nam-gu, Yeonsu-gu, Namdong-gu, Bupyeong-gu, Gyeyang-gu, Seo-gu, Ganghwa-gun
	Gyeonggi-do (30)	Suwon-si, Seongnam-si, Anyang-si, Bucheon-si, Gwangmyeong-si, Pyeongtaek-si, Ansan-si, Gwacheon-si, Osan-si, Hwaseong-si, Siheung-si, Gunpo-si, Uiwang-si, Hanam-si, Yongin-si, Icheon-si, Anseong-si, Gimpo-si, Gwangju-si, Yeoju-gun, Yangpyeong-gun, Uijeongbu-si, Dongducheon-si, Goyang-si, Guri-si, Namyangju-si, Paju-si, Yangju-si, Pocheon-si, Yeoncheon-gun, Gapyeong-gun

(B) Definition of U-City Security Service

Before examining the effect of U-City security service on crime rates, U-City security service should first be defined. South Korea is currently executing 'the secondary Ubiquitous City (U-City) Comprehensive Plan (2014–2018)' under the leadership of the Ministry of Land, Infrastructure, and Transport (MOLIT). One of the major initiatives of this plan is the U-City security service. U-City security service aims to build U-City integrated operation center that unifies existing CCTV control, transportation, and facility management centers to avoid redundant investment, and to enhance the efficiency of urban management and social security. Many regions are now operating with integrated CCTV control centers that unify various systems, yet not all of these regions are included in the Ubiquitous City Comprehensive Plan. Therefore, regions with U-City Security in this study mean all localities where either U-City operation center or integrated CCTV control center is run.

(C) Research Model and Analysis Method

This study will adopt the spatial regression model to examine the relationships between crime rates and multiple explanatory variables by controlling spatial effects. Taking into account that previous studies considered the spatial dependence of crime rates and used spatial regression models as a research method, the current study first examines whether spatial autocorrelation of crime rates exists. If the spatial autocorrelation exists, this study will use spatial regression model or multiple linear regression model as a research method.

Variables are chosen based on previous studies on the factors that influence crime rates, in addition to the variable to figure out the effect of the U-City security service on crime rates.

1) Dependent Variable: The dependent variable for this study is the number of five types of violent crime (robbery, rape, sexual abuse and indecent assault) cases per 100,000 population, using data from the Korean National Policy Agency on violent crime cases in 2012. Violent crime cases are divided by resident registration population in 2012 to control local population size.

2) Explanatory Variables: Explanatory variables are categorized into five groups: demographic, socioeconomic, physical, defense mechanism, and U-City security service variables [13][16][19][28][33].

(a) Demographic Variables: Crime is a phenomenon caused by human interaction. Thus, previous studies have included demographic variables as major factors that influence crime rates. Primarily selected demographic variables based on previous studies, include resident registration population, population density, infant population rate, aged population rate, and per household population. Variables

showing high correlation with others are removed to identify the best subset among these variables. As a result of this process, population density and per household population are used as explanatory variables in the analysis.

Regarding research on the effect of population density on crime rates, previous studies have found conflicting results as to whether high population density has a positive or negative effect on crime rates. One argument is that high population density has a negative (-) effect on crime rates because of increasing resident registration population. Other studies indicate that high population density has a positive (+) effect on crime rates, which was explained to increase the stress level of residents because of social contact or the high possibility of social involvement; these factors can also have the potential factor affecting offenders to commit a crime [16][28][33]. This study attempts to identify whether population density has positive or negative effect on crime rates. Population density is calculated by dividing the resident registration population by local area. Data for resident registration population are recorded by Korean Statistical Information Service (KOSIS) whereas data for local area are recorded by the Statistics of Land Registration.

Previous studies have used per household population under the assumption that the higher per household population acts as a social defense for a crime, that is, per household population has a negative (-) effect on crime rates [13][16]. In this study, per household population is calculated by dividing resident registration population by the number of households and data from KOSIS.

(b) Socioeconomic Variables: Social disorganization theory suggests that the socio-economic level of each region affects social control and thus, low socio-economic level increases crime rates [16][28]. Recipients of national basic livelihood ratio and the amount of property tax per population are chosen as socio-economic explanatory variables.

In general, the higher the recipients of national basic livelihood ratio, the lower the income level of a region. A region with lower economic level has higher level of crime rates because social control is relatively weak, making it almost impossible to suppress criminal motives [16][28]. Recipients of national basic livelihood ratio are calculated by dividing the number of recipients of national basic livelihood by the resident registration population of each region; the data were obtained from the enrollment of recipients of basic livelihood and people with disabilities of Statistics Korea.

As for the amount of property tax, previous studies are unclear as to whether the amount of property tax has a positive or negative effect on crime rates. One view indicates that property tax has a positive (+) effect on crime rates because it is more likely to be the target of crime, whereas, the other argues that the amount of property tax has a negative (-) effect on crime rates because households with higher property taxes have a better defense mechanisms, such as security

equipment and security guards. This study attempts to identify whether the amount of property tax per population has positive or negative effects on crime rates [16][33]. Data were collected from the property tax burden of the local tax statistics of each region, and are calculated by dividing the property tax burden by resident registration population of each region.

Physical Variables

Residential area ratio, commercial area ratio, industrial area ratio, park area ratio, and the number of entertainment establishments are chosen as physical variables. Among these factors, residential area ratio, commercial area ratio, and the number of entertainment establishments are chosen based on the correlation with other variables.

Variables regarding residential area include the number of apartments, residential area ratio, and apartment ratio. According to previous studies, a residential area is less likely to be vulnerable to violent crime incidence because of the limited flow population in residential areas [4][5][16][33]. Residential area ratio refers to the proportion of residential area to the total area in each region and the data used are obtained from the statistics of the Land Registration.

Regions with high commercial area ratio are more likely to be exposed to crime, especially larceny and violence [13][16][33]. Commercial area ratio is calculated by dividing commercial area by the total area of each region using data from the statistics of land registration.

Entertainment establishments refer to the type of businesses that is designated as entertainment establishments by the Act on the Regulation of Entertainment Establishments. A large number of liquor stores and bars contribute to increased neighborhood crime rates, and alcohol consumption tends to cause criminal offense [1][8]. Empirical studies have also revealed that the number of the entertainment establishments has a positive (+) effect on crime rates [12][15][21]. In the current study, the number of the entertainment establishments is the sum of the number of karaoke and general bars that create harmful environment to the city using data from annual statistics report of Seoul, Incheon, and Gyeonggi-do.

(a) Defense Mechanism Variables

Previous studies have included defense mechanism variables as explanatory variables to examine their effects on crime rates according to routine activity approach. Routine activity approach is one of the traditional criminal opportunity theories. The approach states that interaction of the presence of potential offenders, subject compliance and the absence of ability to protect [6][34]. The number of police stations and CCTVs in each region is selected as defense mechanism variables in this study.

The police force is considered strong when the number of police officers is large. Few preceding studies indicate strengthened police force as being representative of the level of defense mechanism, which has sustained negative (-) effect on crime rates [13][22[25][33]. Other studies argue that the concentration of criminal acts results in an increased police force [7]. Data on the number of police stations are from the annual statistics report of each region and Korean National Police Agency.

The number of CCTVs include only CCTVs for crime prevention installed by local police agencies using data from Korean National Police Agency. Previous studies have investigated the effects of the number of CCTVs on crime rates, individually, and notwithstanding other factors [24], but much is still unclear. With regard to the effects of CCTVs, studies revealed mixed findings; while some studies found that CCTVs have a negative (-) effect on crime incidence, others suggested that installation of CCTVs as not being an effective solution to reduce crime rates [24][26][29][35]. Therefore, this study will examine the effects of the number of CCTVs on crime rates by controlling other factors.

(b) U-City Security Service Variable

Although U-City security service has been applied in many cities along with Ubiquitous City Comprehensive Plan, empirical studies investigating the effects of U-City security service on crime rates have been woefully deficient [14]. Therefore, this study aims to analyze empirically the effect of U-City Security Service on crime rates in 2012, the year when the plan entered its fourth year. U-City security service variable is a dummy variable; regions operating integrated control center have a value of 1 and others have a value of 0.

Table 3
Variables of Analysis

Name of Variables		
Dependent Variable	*Violent crime cases per 100,000 population*	
Explanatory Variables	Demographic Variables	Population density
		Per household population
	Socioeconomic Variables	Recipients of the national basic livelihood ratio
		Amount of property tax per population
	Physical Variables	Residential area ratio
		Commercial area ratio
		Number of entertainment establishments
	Defense Mechanism Variables	Number of police stations
		Number of CCTVs for crime prevention
	U-City Security Service Variable	

Descriptive statistics of these variables are shown in [Table 4] below.

Table 4
Descriptive Statistics

Variables		*Unit*	*Obs.*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Violent crime cases per 100,000 population		Cases/person	62	52.78	21.13	27.00	154.40
Demographic variables	Population density	1000 people/km^2	62	9.47	8.22	0.07	28.50
	Per household population	Person/household	62	2.53	0.29	1.89	3.75
Socioeconomic variables	Recipients of national basic livelihood ratio	Person/person	62	2.06	0.95	0.61	5.84
	Amount of property tax per population	Million won	62	200.69	120.82	73.51	697.23
Physical variables	Residential area ratio	%	62	30.82	28.58	0.47	95.14
	Commercial area ratio	%	62	3.24	5.54	0.02	36.35
	Number of entertainment establishments	Count	62	235.32	172.23	9.00	724.00
Defense Mechanism variables	Number of police stations	Count	62	14.45	6.92	3.00	35.00
	Number of CCTVs for crime prevention	Count	62	456.28	360.04	63.91	1,902.82
U-City Security Service		Dummy	62	0.50	0.50	0.00	1.00

IV. ANALYSIS RESULTS

(A) Exploratory Spatial Data Analysis

Before analyzing the effect of U-City security service on crime rates, the current study conducted an exploratory spatial data analysis to identify the spatial pattern of crime rates in Seoul and to confirm the existence of spatial effects. First, it looks at the distribution of violent crime incidences and then identifies the existence of spatial dependence through Moran's I.

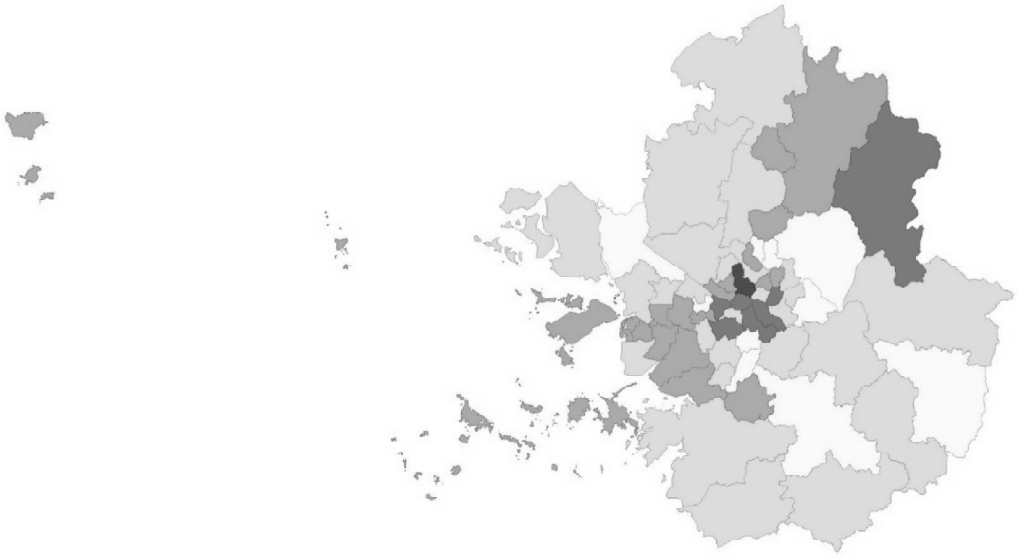

Figure 1: The Spatial Distribution of Violent Crime rates

Figure 1 shows the spatial pattern of violent crime rates in the Seoul metropolitan area, which was subdivided into 62 regions using the classification criteria used of Natural Break. As shown in [Figure 1], the darkest brown colored areas indicate the highest incidences of violent crimes. The top three regions with the highest violent crime rates are Jung-gu, Jongno-gu, and Yongsan-gu. Based on the distribution of violent crime rates in the map, the spatial distribution of high violent crime rates occurring in their neighborhoods are located on the center of Seoul.

[Figure 2] presents the Local Indicators of Spatial Association (LISA) Cluster Map of crime rates using the spatial weight matrix of Queen Contiguity (order of contiguity=2). Regions with dark red color refer to HH (High-High) regions where both the region and surrounding regions recorded high crime rates, while regions colored dark blue refer to LL (Low-Low) regions where both the region and surrounding regions recorded low crime rates. The HH and LL regions denote the

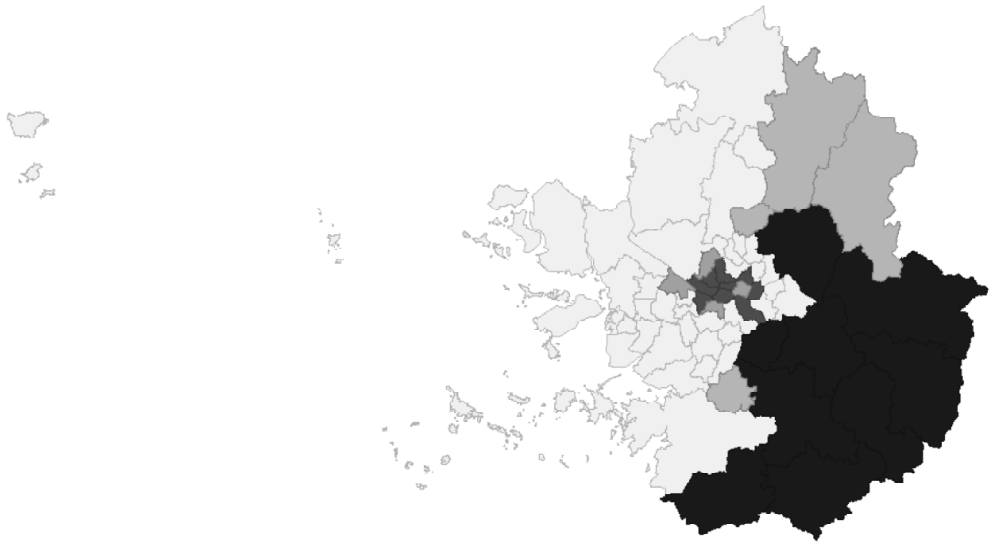

Figure 2: LISA Cluster Map of Crime rates

regions with positive spatial autocorrelation..HL (High-Low) and LH (Low-High) regions are where the distribution of crime rates of the region and the surrounding regions differ, and these regions denote negative spatial autocorrelation. HH regions are clustered clearly in the center of Seoul, while LL regions are clustered at the southeastern side of Gyeonggi-do. The LL regions appear to be the most widely distributed but the number of HH regions and that of LL regions are the same.

This study then reviewed the spatial dependence of crime rates of the 62 regions in Seoul metropolitan area using Moran's I index. Moran's I index, when applying spatial weight matrix of Queen Contiguity (order of contiguity=1), is 0.236 and the result is statistically significant, which means a positive spatial autocorrelation in violent crime cases per 100,000 population exists. A positive spatial autocorrelation using spatial weight matrices of Rook Contiguity (order of contiguity=1) has been identified, 4-nearest, and 6-nearest. As a result, a positive spatial autocorrelation using all spatial weight matrices exists, although a slight difference between Moran's I index depending on the spatial weight matrices.

Table 5
Result of Estimating Moran's I index

	I	*E(I)*	*sd(I)*	*z*	*p-value*
Queen contiguity	0.236	-0.016	0.071	3.553	0.004
Rook contiguity	0.251	-0.016	0.075	3.601	0.002
4nearest	0.226	-0.016	0.071	3.421	0.005
6nearest	0.182	-0.016	0.057	3.475	0.002

(B) Effects of U-City Security Service on Crime Rates

Because spatial autocorrelation in crime rates within Seoul metropolitan area has been proven, this study analyzes the effect of U-City security service on crime rates by estimating a spatial regression model. First, Lagrange Multiplier (LM) tests are conducted by applying four types of spatial weight matrices. The results show that SLM (Spatial Lag Model) is the most appropriate model to analyze the effect of U-City security service on crime rates.

Table 6
Result of Lagrange Multiplier Tests

	Queen contiguity	*Rook contiguity*	*4-nearest*	*6-nearest*
LM (lag)	4.1544 (0.04153)	4.5344 (0.03322)	1.7256 (0.18897)	4.4600 (0.03470)
Robust LM (lag)	7.1952 (0.00731)	7.5164 (0.00611)	4.2128 (0.04012)	7.2340 (0.00715)
LM (error)	0.0164 (0.89819)	0.0657 (0.79767)	0.2135 (0.64402)	0.0156 (0.90049)
Robust LM (error)	3.0572 (0.08038)	3.0476 (0.08085)	2.7006 (0.10031)	2.7897 (0.09487)

The results of analysis on the effect of U-City security service on crime rates using spatial regression models are shown in the following [Table 7].

The adjusted R-squared of the model is 75.5%. The result of Breusch-Pagan test indicates that the model does not suffer any problem of heteroscedasticity. The likelihood ratio test was used to verify whether spatial dependence exists. The result of the SLM shows that all variables have an effect on crime rates at a statistically significant level except for the number of police stations and U-City security service variable.

According to the results of the analysis, the application of U-City security service is not statistically significant, which, in other words, does not have an effect on crime rates, while regions with U-City security service are expected to have lower crime rates. This appears to be because the installation of U-City security service is decided by budget or policy purposes, rather than the level of crime rates. Otherwise, it is only 3 years after the enforcement of the primary Ubiquitous City Comprehensive Plan; hence, the real effects of the U-City security service is necessary that ID in more recent times and to compare crime rates before and after the application of the U-City security service.

Population density, one of the demographic variables, was found to have a positive (+) effect on crime rates. This result suggests that the current study supports the argument of some studies that found that a high level of population density

Table 7
Result of Spatial Regression Analysis

Variables		*Coef.*	*Std. Err.*	*t-stat*	*Prob*
Weighted (violent crime cases per 100,000 population)		0.272513	0.123245	2.211153	**
Demographic variables	Population density	1.044823	0.264628	3.948271	***
	Per household population	-21.2152	5.580164	-3.8019	***
Socioeconomic variables	Recipients of national basic livelihood ratio	0.065836	0.016114	4.08563	***
	Amount of property tax per population	3.61444	1.764742	2.048141	**
Physical variables	Residential area ratio	-0.17804	0.08451	-2.10676	**
	Commercial area ratio	1.405637	0.395402	3.554957	***
	Number of entertainment establishments	0.045811	0.010557	4.33946	***
Defense Mechanism variables	Number of police stations	-0.2473	0.279316	-0.88537	
	Number of CCTVs for crime prevention	-0.00904	0.004567	-1.97988	**
U-City Security Service		1.72545	3.221578	0.535592	
constant		58.4471	17.2587	3.386529	***

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

increases the stress level of social interaction, resulting in an increase in crime incidence. In accordance with previous researches, per household population negatively (-) affects crime rates because more people in each household are able to prevent crime effectively.

Both recipient of national basic livelihood ratio and amount of property tax per population, which are categorized as socioeconomic variables, are found to have positive (+) effects on crime rates. Arguments have been raised on the effects of the amount of property tax on crime rates. This study confirms that regions with high level of property tax become targets of violent crimes. Similar to the results of previous studies, this study also revealed that regions with higher ratio of the recipient of national basic livelihood present low level of economic status, which are eventually likely to have more violent crime incidence.

The result of residential area ratios suggests that it has a negative (-) effect on crime rates, to prove the argument of previous studies that residential area is less vulnerable to violent crime incidence. Commercial area ratio and the number of entertainment establishments are found to have positive (+) effects on crime rates, which is similar to those obtained from previous studies. Regions with commercial areas appeared to be prone to violent crime incidence. The abundance of entertainment establishments in a region are also found to be associated with the higher crime rates of the region.

Among defense mechanism variables, the effect of the number of police stations on crime rates is not statistically significant. The result also shows that the number of CCTVs have a negative (-) effect on crime rates, indicating that CCTV is a good means of defense against crime.

V. CONCLUSION

This study analyzed the effects of the U-City security service on crime rates within the Seoul metropolitan area in 2012. The Seoul metropolitan area was classified into 62 regions by estimating a spatial regression model. Before estimating the model, the study conducted ESDA by examining the spatial pattern of crime cases per 100,000 population and confirmed the existence of spatial autocorrelation on crime rates. The analysis found that areas at the center of Seoul had higher levels of crime rates, a statistically significant spatial autocorrelation in crime rates can be observed. Thus, this study used a spatial regression model instead of the multiple linear regression model. Urban characteristics variables used in the model, other than the existence of U-City security service, are selected after reviewing previous studies. As a result of the analysis of the spatial regression model, the U-City security service has a statistically insignificant effect on crime rates. These results can be attributed to the unambiguous criteria to apply U-City security service in each region and the effects of U-City security service to reduce crime rates, was

not displayed for 2012. Population density, the recipient of the national basic livelihood ratio, the amount of property tax per population, commercial area ratio, the number of entertainment establishments, and the existence of metropolitan policy agency all have a positive (+) effect on crime rates, whereas population per household, residential area ratio, and the number of CCTVs have a negative (-) effect on crime rates.

The current study provides insights into the extent to which U-City security service has an empirical effect on crime rates. The study also clarified the effects of urban characteristics on crime rates that were vague in previous studies. However, this study has a limitation that should be considered when collecting data for the analysis. The analysis was conducted in a single year, but because of the lack of data, researchers cannot observe variations of crime rates a year after the application of U-City security service. However, if the data is already established, analyzing the effects of U-city Security Service by using the cost spent on building U-City Security Service rather than dummy variable would be a more effective approach. Therefore, additional research is necessary to examine whether U-City security service positively affects crime rates.

Acknowledgement

This work is financially supported by Korea Minister of Ministry of Land, Infrastructure and Transport(MOLIT) as 0U-City Master and Doctor Course Grant Program

References

[1] Block R. and Block C. R. (1995). Space, Place, and Crime: Hot Spot Areas and Hot Places of Liquor-related Crime. in Crime and Place Eds. J Eck, D Weisburd, Willow Tree Press, Monsey, NY.

[2] Brantingham, P.L. and Brantingham, P.J.(eds). (1981) Environmental Criminology. London: Sage.

[3] Chainey, S. and Ratcliffe, J. (2005). GIS and Crime Mapping. Chichester: John Wiley and Sons Ltd.

[4] Choi, C. S. and Hwang, C. G. (2014) On the Relationship of U-Security Service, Usefulness and Citizen Satisfaction. JKIECS, 9(8), 875-882.

[5] Choi, D. B. (2005). A Study on Crime Occurrence and Prevention Measures in accordance with Residential Environment (Masters dissertation). Inha University, Incheon, Korea.

[6] Cohan L. E. and M. Felcon, (1979). Social Change and Crime Rate Trends: A Routine Activities Approach. American Sociological Review 44: 588-608.

[7] Ehrlich, Isaac and Randall Mark. (1977) Fear of Deterrence: A Critical Evaluation of the 'Report of the Panel on Research on Deterrent and Incapacitation Effects'. Jouranl of Legal Studies, 6(2), 293-316.

[8] Fagan, J. (1990) Intoxication and aggression. In M. Tonry & J. Q. Wilson. (Eds.). Drugs and crime. Chicago: The University of Chicago Press.

[9] Georges, D. E. (1978). The geography of crime and violence. Washington, DC: Association of American Geographers.

[10] Heo S. Y. et el (2009). Spatio-temporal Pattern of Urban Crime and the Correlation between Crime Rate and Spatial Structure, Journal of Korea Planning Association, 49(3), 399-406.

[11] Herbert, D.T. and Hyde, S.W. (1985) Environmental Criminology: Testing Some Area Hypotheses. Transactions of the Institute of British Geographers New Series, 10, 259-274.

[12] Jeon, J. H. et el. (2007) Spatial Crime Analysis using GIS. Journal of the Korean Society for Geo-Spatial Information System, 15(1), 3-7.

[13] Jeong, K. S. (2010) The Spatio-temporal Patterns of Urban Crime and Its Influencing Factors using Integrated Model of Spatial Crime Analysis (Doctors dissertation). Gyeongsang National University, Jinju, Korea.

[14] Jeong, K. S. and Park, S. S. (2005). U-City and Crime Control. Institute of the Social Sciences, 12(1), 5-34.

[15] Jeong, K. S. et el. (2009) Analysis of Spatio-temporal Pattern of Urban Crime and Its Influencing Factors. Journal of Korean Association of Geographic Information Studies), 12(1), 12-25.

[16] Jung, S. Y. (2008) The Spatial Pattern Analysis of Urban Crime and its Influencing Factors using GIS and Spatial Statistics: A Case Study of Seoul, Korea (Masters dissertation). Seoul National University, Seoul, Korea.

[17] Kang, W. and Kwak, D.H. (2008). Place-Based Policing and Policy Implications. Police Journal, 8(2), 61-87.

[18] Kim, H. J. and Lee, S. W. (2010). Changes in Spatial Dependence of Crime and Distribution of Crime Hot Spots in Korea, 2001-2010. REIK, 11(2), 27-41.

[19] Kim, J. S. (2009) The Effects of Environmental Characteristics on Crime (Masters dissertation) Kyonggi University, Suwon, Korea.

[20] Kim, S. I. et el. (2010). A Study on Crime Factors in Korean Urban Area, Public Administration Studies, 11(1), 109-133.

[21] Ko, J. H. (2001) Crime Patterns of CBD in Cheongju City. Journal of Economic Geographical Society of Korea, 36(3), 329-341.

[22] Ko, J. H. (2009) Spatial Aspects of Crime and Fear of Crime (Doctors dissertation). Korea National University of Education, Cheongju, Korea.

[23] Korean National Police Agency. (2015) Korean National Policy Agency Crime Statistics.

[24] Lee, H. J. (2015) The Study about the Influence of the Urban Characteristics on the Incidence of Crime: Using Panel Data and Panal Model (Masters Dissertations). Pusan National University, Busan, Korea

[25] Lee, T. G. (2010) A Study on the Causes of Crime Occurrence: With an Emphasis on Urban Areas (Masters dissertation). Kyunghee University, Seoul, Korea.

[26] Lim, S. J. (2010) An analysis for the effectiveness and utilization of the CCTV on crime prevention and arrest (Masters dissertation). Korea University, Seoul, Korea.

[27] Ministry of Land, Infrastructure and Transport(MOLIT). (2015) Statistics of Urban Planning.

[28] Oh, M. J. (2011) A Study on the Characteristics of Urban Environment Influencing Crimes: Focusing on 5 Major Crimes (Masters dissertation). Hongik University, Seoul, Korea.

[29] Park, C. H. and Choi, S. H. (2009). Crime Prevention Effects of Publicity of CCTV Installation at Kang-Nam Gu, Seoul: The Effects of First News. Korean criminological review, 79, 213-238.

[30] Shaw, C. R. and H. D. Mckay. (1972). Juvinile Delinquency and Urban Areas. Chicago: University of Chicago Press.

[31] Supreme Prosecutors' Office. (2015) Crime Analysis Statistics.

[32] Weisburd, D. (2008). Place-Based Policing. Ideas in American Policing, 9, 1-15.

[33] Yang, J. S. (2010) A Study for Preventing Urban Crimes Using CPTED Methodologies (Doctors dissertation). Anyang University, Anyang, Korea.

[34] Yim, H. N. et el. (2015) An Empirical Study on Gender Differences in Causes of Adolescent Victimization from Perspectives of Self-Control Theory and Routine Activity Theory, The Korean Association of Police Science Review, 17(3), pp.273-298.

[35] Yim, M. H. and Hong, J. H. (2008). Directions of Crime Prevention Policy Through the Analysis of Crime Prevention Effects of CCTV, Korean Associate for Policy Sciences, 12(4), pp.77-101.