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Exploring the Relationship between Place and Crime Using Spatial Econometrics Model

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Abstract

The purpose of this study is to examine the spatial characteristics of violent and burglary crimes in South Korea. Violent crimes and burglary crimes depend on a spatial setting with good conditions for their criminal purposes. This study defines population density, racial heterogeneity, types of houses, and density of commercial facilities as variables of place affecting crime in cities and counties. The study collects data from 229 cities in Korea to analyze the effect of spatial characteristics on crime. We conduct additional analyses to meet the statistical requisites of the spatial econometrics model using the open-source software R and GeoDa 1.12.1.129. From the analytical result, population density, racial heterogeneity, apartments, and commercial areas relate to crime occurrence. We suggest the implication of the theoretical and practical contributions to the relationship between place and crime.

Keywords: *Place, Crime, Spatial Econometrics Model, Sociology, Environmental Criminology*

1. INTRODUCTION

Crime can be interpreted in two contexts: place and time. The key keyword related to the place is a hot spa. Hot spot policing has gained popularity since the onset of CompStat [1]. This place-based policing strategy assumes that crime concentrates in relatively small geographic areas. This conventional place-based strategy accounts for the relationship between crime and place. The time dimension of crime events is, on the other hand, not taken into consideration since the duration of police interventions is largely fixed, usually for a relatively extended period of time [2]. Determining a crime occurrence time is a vital clue for a criminal investigation since it is a powerful tool to prove the alibi of the criminal suspect. Deciphering patterns of occurrences in place can have significant implications for the interdiction of committing a crime. Police agencies can prioritize the deployment of resources based not just upon ‘‘where’’ but also upon the associated ‘‘when’’ crimes are most likely to cluster [3].

In particular, academic interest in the relationship between crime and place has its origins in sociology and environmental criminology. Sociology has limitations in the methodology for understanding the physical world or geographic environment existing in society. Environmental criminology presents the category of crime places to understand and explain specific crime locations and types of crimes using a geographic information system. In other words, environmental criminology focuses on the geographic and social characteristics of the criminal place.

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The impact of the physical environment on human behavior has been widely noted. In the thoughtful essay on the sociology of place, there has been a strong argument for incorporating the notion of place into sociological analyses [4]. The ecological environment is an objective reality that influences human behavior. Behavior settings have standing patterns of social activity that persist even as the participants change [5]. The sociology of place infers the interaction or correlation between place and human behavior, a crime, based on the premise that place affects human behavior. This scholarly perspective supports the hypothesis that factors consisting of the physical world, such as space or place, cause and deters crimes. The spatial concept of modern society has been expanded and evolved more complexly than in the past. Places are different in terms of power, size, gender, race, and class. Places also act and have an impact on social interactions and other social phenomena. From a criminological approach, the physical world is regarded as a factor influencing human criminal behavior For crime, a place may manifest certain features that foster and support crime. By identifying these features, a social community can begin to formulate place-specific crime prevention strategies [6].

Environmental criminology critically examines the link between crime and physical location and how our activities are spatially shaped [7]. Environmental criminology studies crime, criminality, and victimization as they have a relationship with place and space and their interaction, especially in the urban background. Its goal is to identify ways to manipulate attributes of the physical environment to reduce opportunities to commit crime at various points in time. A crime finds benefit in certain locations as criminals gravitate to vulnerable and lucrative places to ply their trade. Conversely, certain places carry a special meaning and are generally off-limits (e.g., churches, synagogues, hospitals, mortuaries) or out of reach (e.g., gated communities, highly monitored corporate offices, remote locations) for many would-be offenders. Thus, in terms of crime, location matters [6]. Other spatial studies relating to crime have discovered that criminals tend to live close to the locations of their crimes, often on the same block or in the same neighborhood [8].

Recognizing that many offenders live close to where they commit crimes is an essential theoretical ground to investigate the relationship between place and crime. There are, however, just a few existing empirical studies with an environmental-criminological approach to examine the relationship between place and crime in the Korean context. In terms of the advanced understanding of the physical world in which crimes are caused, we believe that the study has research value and meaning to identify the characteristics of places influencing crimes.

The purpose of this study is to examine the spatial characteristics of two types of offenses, violent and burglary, in South Korea. The two types of crimes have increased since the 2000s. Violent crimes and burglary crimes depend on a spatial setting with good conditions for their criminal purposes, characteristics of which can contribute to clarifying the relationship between place and crimes that this study investigates. Comparing this study with other studies in Western countries, we can find differences in understanding and explaining the relationship between place and crime. Furthermore, this study will contribute to the applicability and development of the theory.

2. VARIABLES AND DATA

The theoretical and empirical connections between place and crime are suggested in the literature but have not been fully developed or tested. In that context, this study aims to examine the correlation between urban spatial characteristics and crime occurrence based on the environmental crime perspective. The environmental crime perspective focuses on the place where a specific crime occurred and the type of crime in certain areas. Characteristics of place relating to crime occurrence include residents, population density, types of housing, racial heterogeneity, density of commercial facilities, socioeconomic vulnerability, and instability in residence [9].

This study defines population density, racial heterogeneity, types of houses, and density of commercial facilities as variables of place affecting crime in cities and counties in South Korea. Population density is the number of people per unit of area, showing the relationship between population concentration and crimes. Changes in levels of racial heterogeneity are associated with changes in the crime rate. Given that racial heterogeneity in Korea has skyrocketed, Korea has become an ethnically homogeneous residence. The percent of foreigners is a variable for measuring the level of racial heterogeneity in Korea. The type of houses has a

relationship with crimes because most of the crime scenes are settlements of criminals and crime victims. We use the number of single-family housing, apartments, and rowhouses as variables to measure the type of houses. In overseas literature, the number of vacant housing is used rather than housing types. In domestic literature, the housing types are used to examine the association between dwelling space and crimes. Commercial areas offer more crime opportunities to commit crimes intentionally or unintentionally. Commercial areas are hot spots, taking up more than 25% of crimes that occurred per year. We use the number of accommodation and merrymaking places as a measurement variable of the density of commercial areas. This study uses the number of violent and burglary crimes as dependent variables, measuring them by standardizing the number of occurrences per 1,000 population to reduce the deviation between cities.

This study collected data from 229 cities in Korea to analyze the effect of spatial characteristics on crime. The source of data collection is Korean Statistical Information Service. The sample period is 2019. Some data were not available in Korean Statistical Information Service, so we collected from statistical yearbooks of 17 regional governments. The number of housing types and the number of accommodation and merrymaking places are unstable for analysis. This study transforms these variables into logarithms to stabilize data.

Table 1. Definition of Variables

Variables		Measurement
Independent Variables		
Population Density		Number of Inhabitants per Square Kilometer
Racial Heterogeneity		(Number of Foreigners/Total Population)×100%
Types of Houses	Single-family Houses	Log(Number of Single-family Houses)
	Apartments	Log(Number of Apartments)
	Rowhouses	Log(Number of Rowhouses)
Commercial Areas		Log(Number of Accommodation and Merrymaking Places)
Dependent Variables		
Violent Crime		Number of Violent Crime per 1,000 Population
Burglary Crime		Number of Burglary Crime per 1,000 Population

This study employs spatial regression analysis to examine the relationship between characteristics of place and crime occurrence. The traditional regression analysis using OLS has the limitation that it cannot reflect the spatial correlation of crimes into our research model because the occurrence of crimes has interaction to place and tends to be concentrated in a specific area.

It is necessary to apply the spatial econometrics model to estimate reliable parameters by reflecting this spatial correlation. We also conduct additional analyses to meet the statistical requisites of the spatial econometrics model using the open-source software R and GeoDa 1.12.1.129. First, we test spatial autocorrelation to verify the application of the spatial econometrics model. Moran's I, Gary's C, Getis, and Ord's G are used to measure spatial autocorrelation. We investigate the spatial autocorrelation using Moran's I. Second, we test the non-normality and heterogeneity of error terms. We use Jarque-Bera statistics to examine the non-normality of the error term and Breusch-Pagan and Koenker-Bassett statistics to confirm the heterogeneity. Third, the spatial dependence on the error term of the data should be tested with the Lagrange Multiplier Diagnostics function because the data in this study are one with spatial characteristics. Finally, this study conducts a spatial regression analysis. Spatial regression models are generally divided into the Ordinary Least Square, the Spatial Lag Model, and the Spatial Error Model. In this work, we try to get analysis results by both the regression model (OLS) that does not properly consider the characteristics of spatial data and Spatial Lag Model (SLM) and Spatial Error Model (SEM) that can solve these problems, and compare the three analytical models to suggest the most appropriate model.

As you can see from Table 2, this study presents data from 229 including cities, counties, and districts. This data is an average of 229, and some variables have been replaced with logs to make the data safe for statistical

analysis. Violent crimes have fewer cases than burglary crimes.

Table 2. Summary Statistics

Variables	M	SD
Number of Inhabitants per Square Kilometer	7,235.77	8,992.47
(Number of Foreigners/Total Population)×100%	2.65	2.07
Log(Number of Single-family Houses)	9.65	0.53
Log(Number of Apartments)	9.88	1.43
Log(Number of Rowhouses)	7.49	1.09
Log(Number of Accommodation and Merrymaking Places)	7.56	0.99
Number of Violent Crime per 1,000 Population	0.59	0.45
Number of Burglary Crime per 1,000 Population	4.14	3.08

This study drew up a regional distribution chart of violent and burglary crimes that occurred in 2019. With the sample number of 229, there was a problem that it was too complex to distinguish the regional distribution of violent and burglary crimes in one chart. This study divided 229 into 17 metropolitan cities that are first-tier administrative divisions in South Korea.

Figure 1 shows the regional distribution of violent and burglary crimes in South Korea in 2019. In the frequency of crime, Seoul Metropolitan City and Gyeonggi Province are higher than other regions, followed by Daegu Metropolitan City, Busan Metropolitan City, Gyeongsangnam-do Province, and Incheon Metropolitan City. As we can see from Figure 2, Seoul Metropolitan City and Gyeonggi Province are the highest in burglary crimes, while Busan Metropolitan City, Gyeongsangnam-do Province, Chungcheongnam-do Province, Gyeongsangbuk-do Province, and Daegu Metropolitan City have similar patterns of crime.

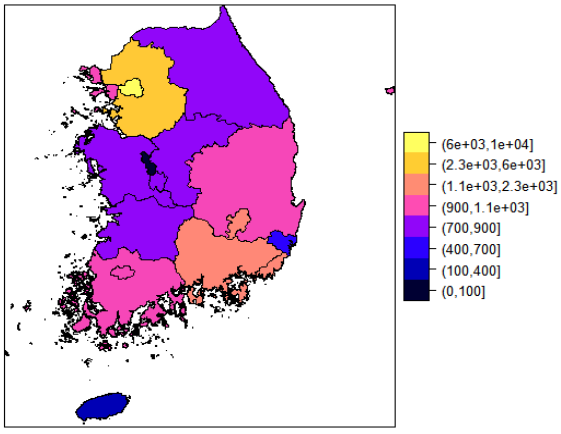

Figure 1. Distribution of Violent Crime

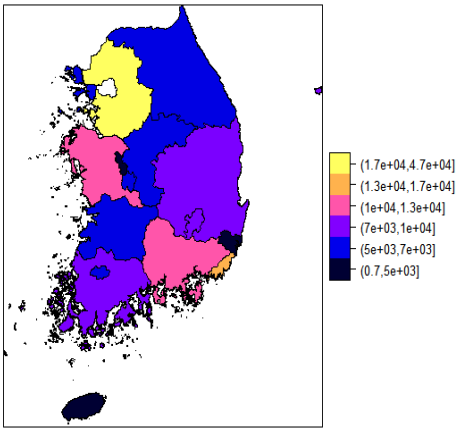

Figure 2. Distribution of Burglary Crime

This study tested spatial autocorrelation to verify the application of the spatial quantitative economic model. In this study, Moran's I, which is used most frequently to test spatial autocorrelation, was used.

$$Moran's\ I = \frac{N\sum_{i=1}^{N}\sum_{j=1}^{N}\omega_{ij}Z_iZ_j}{S_0\sum_{i=1}^{N}Z_i^2}$$

where
N: the number of regions to be analyzed
ω_{ij}: spatial weight between two points i and j
Z_j: ratio that occurs in the region j at the center of mean ratio
S_0: sum of weight values

Spatial autocorrelation analysis was conducted using Moran's I for violent and burglary crimes in 229 regions. The analytical results showed that violent crime (Moran's I = 0.1956) at a significant level of 0.01 and burglary crime (Moran's I = 0.0875) at a significant level of 0.05 had spatial autocorrelation, which means regions with similar spatial characteristics have similar spatial patterns.

We employed Jarque-Bera statistics and Breusch-Pagan and Koenker-Bassett statistics to test the non-normality and heterogeneity of error terms. The non-normality test of the error term showed that the Jarque-Bera statistic at the significance level of 0.01 was 10601.968, which was significant. Testing heterogeneity showed that the Breusch-Pagan statistic was 835.0515 at a significant level of 0.01 and the Koenker-Bassett statistic was 48.3803. Both non-normality and heterogeneity tests of error terms presented that they meet statistical tolerances, indicating that they satisfy the prerequisites of spatial regression analysis.

This study used the Lagrange Multiplier Diagnostics function to test the spatial dependence on the error term of the data. The formula for calculating the value of the Lagrange Multiplier Diagnostics function is as follows.

$$LM = (1/T)((e'We)/\sigma^2)^2 \sim \chi^2(1)$$
$$T = tr(W + W')*W$$

where
W: spatial weights matrix
e: residuals by least squares regression

Testing spatial dependence showed that both LM-Lag and LM-Error spatial dependence were rejected at the significance level of 0.01. Furthermore, the significance probability of Robust LM-error (0.00292) was more significant than Robust LM-lag (0.00913), indicating that the Spatial Error Model (SEM) was more appropriate than the regression model (OLS).

3. ANALYSIS AND RESULTS

Spatial regression can be performed by regression model (OLS), Spatial lag Model (SLM), and Spatial Error Model (SEM). However, to solve the problem of regression models (OLS), we perform both Spatial Lag model (SLM) and Spatial Error Modes (SEM) simultaneously. This study compares the three analysis results and presents the most appropriate model. Formulas of SLM and SEM are as follows.

Spatial Lag Model : $y=\sigma Wy + X\beta + \mu$

where

W: weight matrix representing adjacent regions
Wy: lag variable of crime weighted by W

μ: error

Spatial Error Model : $y=X\beta+(I-\lambda W)^{-1}\mu$

Where

$(I-\lambda W)^{-1}$: spatial multiplier

μ: error

As can be seen from Figure 3, for the spatial regression analysis by the OLS model, population density, racial heterogeneity, apartments, and commercial areas have a significant impact on violent crime at a significant level of 0.01. The result of spatial regression analysis by SLM is similar to those of spatial regression analysis by OLS. From SEM, single-family houses at a significant level of 0.1 and population density, racial heterogeneity, apartments, and commercial areas have a significant impact on violent crime at a significant level of 0.01.

The spatial regression analysis by OLS shows that population density, apartments, and commercial areas

have a significant effect on burglary crime at a significant level of 0.01. The result of spatial regression analysis by SLM is similar to those of spatial regression analysis by OLS. In the analysis of spatial regression by SEM, racial heterogeneity has a significant effect on burglary crime at a significant level of 0.1. Population density, apartments, and commercial areas affect burglary crime at a significant level of 0.01.

The coefficients and R^2 of SLM and SEM of violent and burglary crime increase rather than the ones of OLS. We can also see an increase in the number of variables affecting crimes in SEM rather than OLS and SLM. Considering these analysis results, we can confirm that SEM has the best fit comparing to OLS and SLM.

Table 3. Spatial Regression Analysis

Dependent Variables	Independent Variables	OLS	SLM	SEM
		Coefficient	Coefficient	Coefficient
Violent Crime	Population Density	0.096$^{***.}$	0.093$^{***.}$	0.096$^{***.}$
	Racial Heterogeneity	0.043$^{***.}$	0.044$^{***.}$	0.043$^{***.}$
	Single-family Houses	0.108	0.110	0.119*
	Apartments	0.417$^{***.}$	0.407$^{***.}$	0.409$^{***.}$
	Rowhouses	0.045	0.040	0.037
	Commercial Areas	0.400$^{***.}$	0.400$^{***.}$	0.408$^{***.}$
	Model Summary	R^2=0.432 F=14.433$^{***.}$	R^2=0.439 F=14.559$^{***.}$	R^2=0.441 F=14.583$^{***.}$
Burglary Crime	Population Density	0.817$^{***.}$	0.858$^{***.}$	0.817$^{***.}$
	Racial Heterogeneity	0.155	0.160	0.160*
	Single-family Houses	0.017	0.015	0.007
	Apartments	2.487$^{***.}$	2.470**	2.440$^{***.}$
	Rowhouses	0.024	0.043	0.039
	Commercial Areas	2.935$^{***.}$	2.902**	2.900$^{***.}$
	Model Summary	R^2=0.369 F=10.664$^{***.}$	R^2=0.370 F=10.671$^{***.}$	R^2=0.376 F=10.662$^{***.}$

* p< 0.1,** p< 0.05, $^{***.}$ p< 0.01

4. DISCUSSION

Both Sociology of place and environmental criminology highlight the crucial role of place in the understanding of crime. Based on the analytical results of this study, excepting single-family houses and rowhouses, the rest of the variables in our research model relate to the two crimes. From the analytical information, we can insist that crimes have a relationship with place especially the environmental conditions caused or created by the characteristics of place. Core concepts and ideas in the sociology of place help understand environmental criminology and, ultimately, prevent crime.

We put the main thought of this study on understanding how spatial factors contribute to crime. From our research, we can get an opportunity to recognize how population density, racial heterogeneity, apartments, and commercial areas relating to place, exactly characteristics of a place, affect crime occurrence. The region with a higher level of population, multiracial culture, many apartment complexes, and many merrymaking places is more likely to be a hot spot with a higher possibility of crime than others. Given that while general causes may motivate the general offender, particular environments often inspire particular types of crime. If we know particular environments coming out of a place, we could specify particular types of crime and the causes. That approach not only highlights the association between place and crime but also gives an advanced understanding of criminology to people researching crimes and working in the criminal justice system. Although modern crime has been becoming brutal and intelligent, backgrounds and stories of crimes can be explained by place

and time because places and time of crimes are the starting point for tracking down the criminal and the vital factor for understanding the incident.

The empirical evidence identifying the association between crime and place can not only change the way to understand crime but also change the way to solve crime. Based on the study, we can emphasize the importance and meaning of place as a key component of a crime view for a better understanding and explanation of crime. We can also provide an opportunity to suggest ideas about how to design and maintain a place to reduce or deter crime.

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