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Crime and environment: Analysis of facilities as crime risk factors in Niš, Serbia

Przestępczość i środowisko: Analiza obiektów jako czynników ryzyka przestępczości w Niszu w Serbii

Abstract: The aim of this study was to examine the relationship between environmental facilities as risk factors and crime. Police data of crimes against property and violent criminal offences registered in 2018 in the city of Niš, Serbia, were geocoded. Grid cells of 100 by 100 metres were designed as the spatial units for analysis, and the geoinformation data of 12 different facilities were extracted from a geographic information system. A negative binomial regression model was constructed to investigate facilities associated with crime. The results suggest that crime is mostly related to facilities such as banks and exchange offices, bus stops, gyms, and recreational centres. On the other hand, cafés, nightclubs, and large shopping centres were not significantly associated with crime. Finally, the limitations as well as the practical and theoretical applications of the research are discussed.

Keywords: crime, environmental facilities, property and violent crime, spatial analysis, risk factors

Abstrakt: Prezentowane badanie ma na celu analizę relacji przestrzeni i obiektów w niej rozmieszczonych oraz przestępczości. W analizach wykorzystano dane policyjne o przestępczości zarejestrowanej w 2018 roku – czynach przeciwko mieniu i z użyciem przemocy popełnionych w mieście Niš w Serbii. Dane te zostały poddane geokodowaniu, względem miejsc zdarzeń przestępczych. Jednostką przestrzenną była komórka siatki o wymiarach 100 na 100 metrów. Dane geoinformacyjne o 12 rodzajach obiektów uzyskano za pomocą oprogramowania GIS. Celem zbadania związku między wybranymi obiektami a przestępczością wykorzystano model regresji dwumianowej. Wyniki przeprowadzonych

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analiz pokazały, że przestępczość występuje najczęściej w przestrzeniach, w których mieszczą się banki, kantory, znajdują się w niej przystanki autobusowe, restauracje, siłownie czy ośrodki rekreacyjne. Nieistotny statystycznie z kolei okazał się związek między występowaniem przestępczości a rozmieszczeniem takich obiektów jak: kawiarnie, kluby nocne czy duże centra handlowe. W artykule zostały omówione także ograniczenia oraz praktyczne i teoretyczne możliwości zastosowania przeprowadzonych analiz.

Słowa kluczowe: przestępczość, urządzenia środowiskowe, przestępczość przeciwko mieniu, przestępstwa z użyciem przemocy, analiza przestrzenna

1. Introduction

The location of crime has been a core theme since the beginning of criminological research and theory. One of the first studies in the field of criminology came from the founders of the cartographic school founders, Adolphe Quetelet and André-Michel Guerry (Ignjatović 2006a: 20). Quetelet and Guerry investigated the impact of the natural, demographic, and social factors on crime and made maps based on their findings, representing differences in the frequency of crime in particular countries and regions (Konstantinović-Vilić et al. 2012: 284–285).

The cartographic school had an impact on the sociological development of the science of crime, the founding of the Chicago school, and the ecological theory of crime. Ernest Burgess (1929) designed a map of Chicago with concentric circles representing zones of crime. Inspired by this work, Clifford Shaw and Henry D. McKay—in their book *Juvenile delinquency in urban areas* (1942)—wrote about the spatial distribution of antisocial events in Chicago. They explained the causation of crime and delinquency in the context of a changing city environment and the ecological development of the city. They identified areas of the city with a low level of crime and those representing the highest crime rates. Based on the demographic, industrial, cultural and ethnical development of the city, they developed the social disorganisation theory (Shaw, MacKay 1942).

Based on an ecological approach to crime, research in spatial criminology continued after World War Two. Lawrence E. Cohen and Marcus Felson (1979) developed the routine activity theory. They suggested a triangle of a crime comprised of a motivated (lately called likely) offender, a suitable target, and the absence of capable guardians, converging nonrandomly in time and space. The influence of the routine activity theory can be found in many types of studies nowadays (Smith, Frazee 2006; Andersen 2009; Weisburd, Morris, Groff 2009). Social psychologists Paul and Patricia Brantingham developed the crime pattern theory and talked about four broad types of urban sites that need to be considered: crime generators, crime attractors, crime-neutral sites, and fear generators (Brantingham, Brantingham 1995). Crime occurs on major pathways and at major nodes where large numbers

of potential offenders are brought together, through routine activities, with large numbers of potential victims and targets (Brantingham, Brantingham 1995: 7). According to their research, crime happens more often in situations and places where people feel more comfortable and safer and show less fear. Crime pattern theory (Brantingham, Brantingham 1993, 1995) combines elements from the rational choice perspective, routine activity theory, and environmental psychology to explain the variation in the spatiotemporal distribution of crime. The theory suggests that rational offenders become aware of suitable targets in the absence of capable guardians while performing their daily activities and routines. Offenders may exploit these opportunities immediately or return to exploit them later. Therefore, crime is the result of the interactions between motivated offenders and their physical and social environment (Vandeviver, Bernasco 2017: 220). In the 1980s, Derek B. Cornish and Ronald V. Clarke began thinking of crime as a rational choice and contributed to the development of the rational choice theory of crime. It is based on the premise that crime happens as a rational choice of an offender who weighs the 'costs' and 'benefits' of a given crime. It argues that offending is purposive behaviour through which offenders seek to benefit themselves (Cornish, Clarke 1986). In their decisions of whether to offend and where to do it, offenders weigh between the costs and benefits of their choices and select the option they expect to achieve the highest profit for themselves. As such, this perspective highlights that crime does not occur at indiscriminate locations, but that the selection of a crime site is the result of a (semi-)conscious decision-making process. This perspective emphasises the fact that an offender's spatial decision-making process is informed by a range of attributes of their physical and social environment (Vandeviver, Bernasco 2017: 220).

Today, many spatial studies of crime emerged thanks to the routine activity theory, the crime pattern theory, and the rational choice perspective. Modern-day criminologists analyse hot spots of crime and its spatiotemporal patterns, mostly using geographic information systems (GIS). Since the late 1980s, followers of this line of research have provided empirical evidence of place concentration using various measures of crime, focussing on different locations of crime and geographic units of analysis, and employing different timeframes of the dataset (Lee et al. 2007: 1).

This study applies spatial analysis methods and explores the influence of environmental facilities on crimes against property and violent criminal acts in the city of Niš, Serbia. Crime data were obtained from police records and geocoded according to the addresses. Spatial units for the analysis, as well as the environmental facilities, were obtained using GIS software. Descriptive and inferential statistical analyses were used to examine the relationship between facilities and crime.

2. Spatial analysis of crime and its risk factors

Jerry H. Ratcliffe (2004) stated that crime is an inherently spatial phenomenon and that crime mapping tends to be point-specific. Whilst some crimes are more difficult to map (internet fraud, tax evasion, and some motoring offences such as driving without a licence), the majority of criminal activity and day-to-day incidents can be analysed spatially. The location of incidents that have to be mapped are usually well known: businesses have thefts at specific sites, residential burglaries occur at houses, and street crimes (assaults and vehicle crimes) often occur outside premises with known addresses (Ratcliffe 2004: 62). These common places of crime are often referred to as crime hot spots. Crime hot spots attract a lot of attention among criminologists, police, and analysts of crime. Hot spots are aggregations of raw crime data designed to identify the sites of highest incident concentration (Ratcliffe, McCullagh 1999: 385). In one of the first empirical pieces of evidence of a highly concentrated crime in space, Sherman, Gartin, and Buerger (1989) analysed spatial data on calls to the police in Minneapolis over one year and found that relatively few 'hot spots' produce most of the calls to the police. Indeed, 50% of all calls originated from only 3% of places. Later studies found more or less similar results. Weisburd and Mazerolle (2000) found that approximately 20 per cent of all disorder crimes and 14 per cent of interpersonal crimes were concentrated in 56 drug crime hot spots in Jersey City, New Jersey. That comprised only 4.4 per cent of street segments and intersections in the city.

Spatial criminology strives to identify those features and facilities in space that influence crime the most. Why do some types of crime happen more often in one type of facility than in others, and why is crime concentrated at certain types of land use? These are the questions that researchers of spatial crime risk factors address the most. Many studies in the field aim to investigate these ecological factors of crime.

These studies include various types of facilities from alcohol outlets in alcohol-related crimes (Bromley, Nelson 2002; White, Gainey, Triplett 2015; Breetzke, Andresen 2018), through retail and shopping centres (Bernasco, Block 2011; SooHyun, Lee 2016), bus stops, petrol stations (Kennedy, Caplan, Piza 2011; SooHyun, Lee 2016; Gerell 2018), pubs, and restaurants (Roncek, Maier 1991; Barnum et al. 2017), to parks and sport and recreation centres (Bernasco, Block 2011; Groff, McCord 2012; Vandeviver, Bernasco 2019). The relationship between crime and these types of features has been studied individually and along with other facilities. For example, some of the studies found that areas with restaurants have higher crime rates: a fast food restaurant serves as a crime generator because of the inexpensive food and anonymous atmosphere favoured by juvenile delinquents during the daytime (SooHyun, Lee 2016: 206). Brantingham and Brantingham (1995) found that bus stops are crime generators as a part of non-residential land use in a recent study. Bernasco and Block (2011) proved that crime occurs more

often in city blocks that consist of various crime generators and crime attractors. Groff and McCord (2012) studied the role of neighbourhood parks as crime generators and they found that neighbourhood parks were associated with elevated levels of crime in the surrounding areas. On the other hand, they also found that some of their characteristics were associated with lower crime levels.

The most common crimes against property and violent criminal acts are the ones that are mostly associated with the above-mentioned facilities. Therefore, most studies deal with crimes such as theft, robbery, burglary, or violent acts. For example, Barnum et al. (2017) applied Risk Terrain Modelling[1] in an analysis of Chicago, Newark, and Kansas City place features and robberies. They found a strong relationship between petrol stations and robberies in Chicago and Newark. On the other hand, Irvin-Erickson (2014) found that drug charges, pawnshops, grocery stores, takeaways, and hair and nail salons impart the strongest criminogenic spatial influences in different time models.

SooHyun and Lee (2016) indicated that previous studies of land use and crime have shown that areas with particular facilities—such as retail shops, schools, and bus shelters—are often high-crime areas, as opposed to areas without these facilities. Therefore, deploying police resources to areas with these facilities would increase the crime prevention benefit (SooHyun, Lee 2016: 207).

3. Research Design and Methods

3.1. Study Area and Data

The city of Niš is the third-most populous city in the Republic of Serbia, with approximately 255,518 citizens. It is the largest city of south-eastern Serbia and the capital of the Nišava District, covering about 597 square kilometres. It is an administrative, legislative, university, business, and cultural centre of south-eastern Serbia. While much of its territory is rural, the urban part of the city is included in this study. The study area was divided into a grid with 100 × 100 meter cells using QGIS software in order to create spatial units for the analysis. In total, the study area consists of 9,000 grid cells of 100 × 100 metres. This proportion was chosen after a literature review of similar criminological analyses (SooHyun, Lee 2016; Hardyns, Snaphaan, Pauwels 2019). Depending on the study, spatial analyses of crime use

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[1]   Risk terrain modeling (RTM) identifies the spatial risks coming from features of a landscape and models how they colocate to create unique behavior settings for a crime. The RTM process begins by testing a variety of factors, including crime risk factors, which are thought to be geographically related to crimes. Valid factors are selected and then weighted to produce a final model that paints a picture of places where crime is statistically most likely to occur (Caplan et al. 2015).

grid cells or administrative boundary as spatial units (Andresen, Malleson 2013; SooHyun, Lee 2016; Vandeviver, Steenbeek 2019). Census data of local communities in Serbia cover much larger territory than the units needed for this study, and the usual spatial units consisting of street segments (Andresen, Malleson 2011; Vandeviver, Steenbeek 2019) are not available in Serbia. Therefore, the decision was taken to analyse the data by grid cells.

The crime data were obtained from the Niš Police department, Ministry of the Interior of the Republic of Serbia[2]. It includes crimes against property and violent criminal offences from the Criminal Code of the Republic of Serbia. Property-motivated crimes include Theft from Article 203 and Aggravated/Compound Larceny from Article 204. Violence-motivated criminal offences in this study include Serious Bodily Harm from Art. 121, Light Bodily Harm from Art. 122, Brawling from Art. 123, Threat with a Dangerous Implement in a Brawl or Quarrel from Art. 124, Violent Behaviour from Art. 344, Grand Larceny from Art. 205, and Robbery from Art. 206. The last two violent acts were included under violent crime, with regards to the divisions of violent and property crime in Western literature (Andresen, Malleson 2011; Hardyns, Snaphaan, Pauwels 2019), in order to compare the results with similar studies. The crime data are from the calendar year 2018.

The raw crime data consisted of the address of every particular criminal offence registered in 2018 in the urban part of the city of Niš, i.e. the name of the street and the house number. Therefore, this data was geocoded in the GIS. The process is applied automatically via Google Earth software. Since approximately 30% of the criminal events could not be geocoded automatically, these were geocoded manually. Finally, 1,175 criminal offences were geocoded, reaching approximately 99% successful geocoding, well above Ratcliffe's (2004) 85%. Criminal offences are shown as point data on the map in Figure 1.

The purposes of this research demanded geocoded data on facilities at risk of crime in the territory of Niš. As this kind of data is not available publicly, it was obtained using the available GIS data. The type of facility was typed into Google Earth's search engine. For example, by typing 'bus stations in Niš, Serbia', the analytical tool of the programme will search and export map point data with all registered bus stations in the city of Niš, using their information and data. Following the methodology described above, the following crime risk facilities were extracted: 1) Banks and Exchange offices, 2) Bus Stops, 3) Cafés, 4) Casinos and bets, 5) Clubs, 6) Petrol Stations, 7) Gyms and Recreation Centres, 8) Parks, 9) Restaurants, 10) Retail Shops, 11) Schools and University Faculties, and 12) Shopping Centres. All of the facilities were hosen for the analysis after a literature review (Roncek, Maier 1991; Bromley,

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[2]   The crime data was initially requested for the purposes of the master thesis "Ecology of crime in urban and suburban area – the importance of explaining a place of crime" defended at the Faculty of Law, University of Niš. However, current study process the data in a completely different level of the analysis.

Figure 1. Map of Niš with point crime data and spatial units
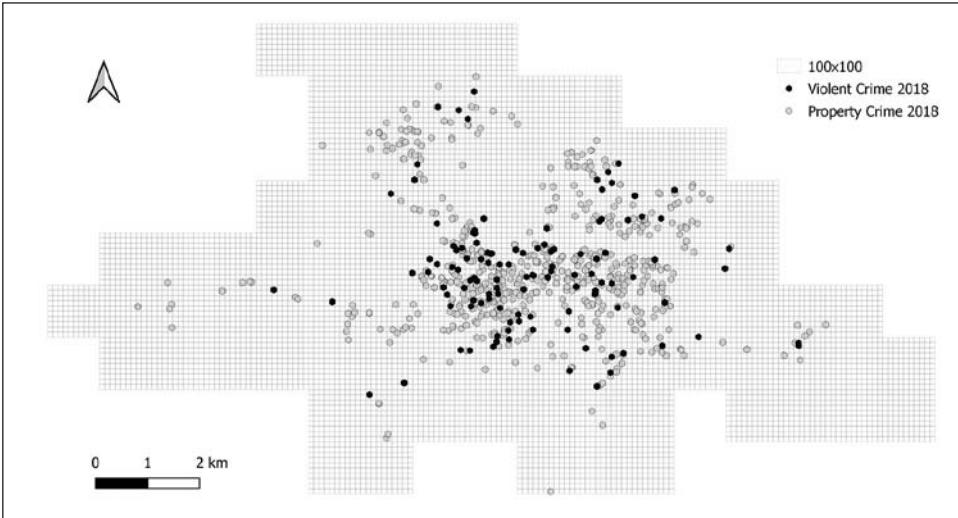
Source: Own research based on Niš Police department, Ministry of the Interior of the Republic of Serbia data

Nelson 2002; Bernasco, Block 2011; Kennedy, Caplan, Piza 2011; Groff, McCord, 2012; White, Gainey, Triplett 2015; SooHyun, Lee 2016; Barnum et al. 2017; Gerell 2018; Vandeviver, Bernasco, Van Daele 2019).

3.2. Statistical Analysis

All of the crimes and environmental facilities were laid on the map of 9,000 100×100 m grid cells. This process assigned all of the crimes and facilities to the corresponding grid cell, making the appropriate data table for the statistical analysis. Data were statistically processed using the programming language R and its freely available software for statistical analysis, RStudio. The dependent variables were property and violent crime, while the independent variables included banks and exchange offices, bus stops, cafés, casinos, clubs, parks, gyms and recreational centres, petrol stations, restaurants, retail shops, schools and faculties, and shopping centres.

Firstly, the data are described using descriptive statistics and measures of variability. Secondly, regression analysis was applied to examine the relationships between dependent and independent variables. Poisson regression and negative binomial regression were used in previous, similar analyses of crime and environmental facilities (Stucky, Ottensmann 2009; Bernasco, Block 2011; SooHyun, Lee

2016) since they have desirable statistical properties when modelling crime data (Vandeviver et al. 2015). Poisson regression analysis was not appropriate due to the overdispersion of the data, manifested in differences between the mean and variance in our crime data (Table 1). Also, the dispersion parameter—alpha—indicates the amount of overdispersion present in the data, as suggested by Bernasco and Block (2011) and Vandeviver et al. (2015). These authors suggest negative binomial regression instead of Poisson regression in this case. Since this model does not assume that the variance equals the mean, but does assume that the mean follows a Poisson distribution, negative binomial regression analysis was done. Two models were constructed in the regression formulas. The first model includes crimes against property as a dependent variable and environmental facilities as independent variables. The second model analyses violent crime as the dependent variable and environmental facilities as independent variables. Due to the potential for multi-collinearity problems, variance inflation factors were examined.

4. Results

Table 1 presents the descriptive statistics of the dependent and independent variables. As we can see, there were 1,028 crimes against property and 147 violent crimes, for a total of 1,175. It is fair to assume that there is a large dark figure[3] behind these numbers since there are several limitations with police data. Firstly, not all incidents are reported to the police. As pointed out by Van Dijk in Philippe (2009: 13), police records only reflect crimes known to police forces. Secondly, crime data is mostly based on aggregate statistics and does not reflect the characteristics of the incidents. He adds that trends in the data may be influenced by policing priorities and practices, which are susceptible to possible manipulation for political purposes. Examples of such shortcomings can be found in the Serbian police crime data. Police data do not include all reported events, only those events which are officially qualified as criminal offences by the public prosecutor and are entered into the criminal record of the police.

The most frequent facilities examined in this study were restaurants, with a count of 199; they are followed by the 189 bus stops. The least frequent facilities were night clubs (8) and large shopping centres (20). The standard deviation varies depending on the variable, with the highest value of 0.77 in property crimes. As we can see in Table 1, there are particular grid cells with a higher number of crimes and facilities. For example, the maximum number of crimes against property occurring in one spatial unit was 33. The maximum number of violent crimes

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3   The dark number in criminology is defined as all crimes which are not reported to or detected by the police.

was 5, while the most frequented facilities in one grid cell were cafés and restaurants (8), suggesting a concentration of dependent and independent variables in specific grid cells. The law of crime concentration (Weisburd 2015) would probably apply to this study area. For example, Sherman, Gartin, and Buerger (1989) explored crime concentration and found that 3% of the places accounted for 50% of the crime in Minneapolis. However, further research is required to obtain empirical evidence on crime concentration. The percentages of grid cells with more than one variable within them are in line with the results. Logically, the most frequent crimes—those against property—are the most widespread (5.9% of grid cells include them), while the less frequent facilities have much smaller percentages of grid cells with any value greater than 0.

Table 1. Descriptive Statistics of Dependent and Independent Variables

Variables	N	Mean	Standard Deviation	Min	Max	% >0
Crimes against property	1028	0.11	0.77	0	33	5.89
Violent crime	147	0.02	0.18	0	5	1.23
Banks and exchange offices	88	0.01	0.13	0	4	0.68
Bus stops	189	0.02	0.17	0	4	1.8
Cafés	110	0.01	0.16	0	8	0.85
Casinos and Bets	58	0.01	0.09	0	4	0.56
Nightclubs	8	0.001	0.03	0	2	0.08
Petrol stations	41	0.005	0.08	0	3	0.37
Gyms and recreation centres	78	0.009	0.10	0	2	0.8
Parks	24	0.003	0.06	0	3	0.23
Restaurants	199	0.02	0.21	0	8	1.56
Retail shops	157	0.02	0.21	0	7	1.11
Schools and Faculties	60	0.007	0.09	0	3	0.58
Shopping centres	20	0.002	0.05	0	2	0.21

Source: Own research based on Niš Police department, Ministry of the Interior of the Republic of Serbia data

Table 2 presents the results from the negative binomial regression analysis. The first model shows regression results for the model of crimes against property as the dependent variable and facilities as independent variables. The second model is an analysis of violent crime as the dependent variable and facilities as independent variables. The results indicate the highest correlation of crimes against property with facilities such as bus stops, gyms and recreation centres, and banks and exchange

offices. A significantly strong correlation exists between crimes against property and restaurants and retail shops ($p = 0$). Schools and faculties, petrol stations, and casinos and bets are also positively correlated with crimes against property. On the other hand, there is no statistically significant relationship between property crime and facilities such as cafés, nightclubs, parks, and shopping centres. The model of violent crime indicates the highest correlation with petrol stations. This is followed by gyms and recreation centres and banks and exchange offices. Violent crime is also positively associated with restaurants, schools and faculties, casinos and bets, and bus stops. Parks are negatively correlated with crime to a statistically significant degree ($p < 0.05$). The rest of the facilities, such as cafés, nightclubs, retail shops, and shopping centres, demonstrated no statistically significant relationships with violent crimes.

Table 2. Estimated relationships between the number of crimes and facilities

Variable	Property Model	Violent Model
Intercept	-2.56497***	-4.530***
Banks and exchange offices	1.43256***	1.620**
Bus stops	1.65076***	1.121**
Cafés	0.43011	1.771
Casinos and Bets	0.79005	1.393*
Nightclubs	0.71019	-1.061
Petrol stations	0.98937*	1.961**
Gyms and recreation centres	1.45195***	1.663**
Parks	-0.89920	-1.121
Restaurants	1.02900***	1.381***
Retail shops	0.88376***	-3.208
Schools and Faculties	1.00071*	1.428*
Shopping centres	-0.03831	-1.862
Log-likelihood	-5141.35	-1262.83
AIC	5169.4	1290.8
Alpha	12.4953	17.4216
Variance inflation factor (mean)	1.19335	1.39310
Variance inflation factor (max)	1.51971	2.13121

*** $p = 0$; ** $p < 0.001$; * $p < 0.01$; $p < 0.05$

Source: Own research based on Niš Police department, Ministry of the Interior of the Republic of Serbia data

The high alpha values for both models (Table 2) indicate highly overdispersed data. Therefore, a negative binomial regression fits the data better than Poisson regression, as suggested by others (Bernasco, Block 2011; Vandeviver, Van Daele, Van Der Beken 2015). The variance inflation factor (VIF) was tested because of the potentially degrading collinearity in our data. The mean VIFs are well below the threshold value of 10 suggested by Bernasco and Block (2011), being approximately 1.2 for the property crime model and 1.4 for the violent crime model. Also, maximum values that represent independent variables with the highest VIF indicate that there was no need to exclude any variable because of collinearity problems.

5. Discussion

This section will discuss the relationship between crime and environmental facilities at the local level and compare the results with similar studies abroad. Banks and exchange offices demonstrated a relationship with both violent crimes and crimes against property; it is even stronger with violent crime. This finding may be influenced by the decision to include robberies with violent crime, as this type of crime may occur more frequently in facilities that handle cash, such as banks and exchange offices. Also, they gather a lot of people and are located in city centres so as to be easily approached by customers. It is suggested by the routine activity theory (Cohen, Felson 1979) that crime occurs near people's main activities and pathways.

Bus stops also showed a significant positive correlation with crimes against property and violent crimes, although the relationship was higher with crimes against property. That is logical since pickpocketing is frequent at large bus stations and on public transport. The crowds provide an opportunity for offenders who decide depending on the chances of being caught. Such offenders weigh the costs and benefits of their actions. These circumstances are connected to the theoretical aspects of both the rational choice theory and the routine activity theory. One study found an 'abundance of negative environmental attributes and a general lack of defensible space elements' at bus stops (Loukaitou-Sideris 1999), so it would be interesting to conduct a broader analysis of bus stops and crime in Niš.

Interestingly, findings from regression analysis suggest that gyms and recreation centres are related to both crimes against property and violent crimes. These facilities gather many people in places such as sports centres, stadiums, gyms and halls, creating their routine activities and pathways (Cohen, Felson 1979). Therefore, a lot of interactions happen, including the opportunity to commit theft or for conflicts between supporters of different sports teams. An interesting perspective on delaying the criminogenic effect of sports stadiums was presented by Vandeviver, Bernasco, and Van Daele (2019). They found that such places remain busy beyond

their opening hours, during which time offenders notice a criminal opportunity and return to exploit it later.

SooHyun and Lee (2016) found that retail shops, bus shelters, and schools are related to crime, similarly to our results. However, they found the strongest correlation with retail shops, which in the current study are positively associated only with crimes against property. The results from the study of Bernasco and Block (2011) also suggest a positive and significant relationship between grocery stores and robberies in the focal block, while the relationship is not significant in the adjusted block. Grocery stores could be comparable to retail shops in our study, where they are positively correlated to crimes against property (Table 2). This relationship is logical if we take a look at a retail shop as a category that includes mini-markets, neighbourhood shops, grocery stores, and all types of shops as pet food, equipment stores, furniture shops, etc. These shops include a lot of cash transactions and therefore represent good opportunities for thieves. They concentrate around such facilities and wait for their chance, making a rational choice to act (Cornish, Clarke 1986).

Contrary to the findings of this study on the relationship between crime and cafés and nightclubs, previous spatial analyses of crime found that these facilities are related to crime. Roncek and Maier (1991) found an association between pubs, taverns, and cocktail lounges and crimes. Bernasco and Block (2011) also found a positive influence of pubs and clubs on robbery counts at the block level. SooHyun and Lee's (2016) findings suggest a positive 'bar club' relation to both crimes against property and violent crime; the current study suggests that cafés and nightclubs are not significantly associated with crime. On the other hand, restaurants—as facilities similar to pubs and taverns—were explored separately in this study. The results suggest a positive, statistically significant relationship between restaurants and crime. This sort of caution on methodology and types of classifications is needed when comparing the findings of different studies. SooHyn and Lee (2016) also reported that restaurants had a positive correlation with the number of crimes against property in the grid cells, as with the results of our study (Table 2).

Their results are in line with the current study which found a positive, significant association between petrol stations and both crimes against property and violent crimes. Interestingly, the correlation is higher with violent crimes that include robberies, as this type of criminal event may be frequent at petrol stations. The results suggest that petrol stations—24-hour facilities with shops and cafés which attract crowds—are places where violent events frequently happen at or nearby. The study of Bernasco and Block (2011) also found that petrol stations are positively associated with robberies.

The study did not corroborate the findings from some other studies that parks are specific crime generators (Groff, McCord 2012). The analysis should be improved further since small grid cells may not best suit the analysis of large facilities such as parks and shopping centres. Some studies found that schools are

a risk factor for crime (Gerell 2018). On the other hand, a study from Philadelphia (MacDonald, Nicosia, Ukert 2018) suggested that school locations play a minimal role in neighbourhood crime production. Schools should be explored in greater detail since primary schools, high schools, and University of Nis's faculties were all merged into one variable in the current research.

6. Conclusions

Let's briefly revisit Figure 1. Crime is concentrated in certain parts of the city, mainly in the centre of the map. This central part represents the city centre with the main promenades. There are cultural monuments that attract crowds—the fortress, the main bus station, several open-air markets, and several shopping centres. This part of the city includes many retail shops, restaurants, banks, and exchange offices. These facilities are related to crimes against property and violent crimes in the results of the study. Also, crime is concentrated in the north-east and north-west of the city, areas with settlements that contain many retail shops and petrol stations. This kind of spatial clustering implies that crime is concentrated around people's main routes, everyday activities, and cultural or business centres.

Crime is a macro-phenomenon that is not independent of its environmental characteristics at the meso- and micro-levels. The ecology of crime has been studied since the beginning of criminological science, with the foundation of the carto-graphic school and the Chicago ecological school. The spatial analysis of crime has produced criminological theories that have had a worldwide impact. These include the routine activity theory, the crime pattern theory, and the rational choice perspective on crime. Thanks to these perspectives, modern criminological studies can produce precise and valuable research on the micro-level of analysis. They use both crime and environmental data processed with GIS technology and statistical packages. These studies include phenomenological and causational exploration of crime.

The aim of the current research was to explore and examine the impact of environmental facilities on crime in the city of Niš, Serbia. Data on crimes against property and violent crime were obtained from police records and were geocoded according to the addresses of the criminal events. The spatial units for the analysis were set as 100×100 metre grid cells, while environmental facilities—representing crime risk factors—were extracted from the GIS. In addition to the descriptive statistics, regression analysis was applied to examine the correlation between crime and environmental facilities. The facilities that proved to have the highest and strongest relationships with crimes against property and violent crimes are banks and exchange offices, bus stops, restaurants, and gyms and recreational centres. Crimes against property are mostly associated with bus stops, gyms and recreation centres,

and banks and exchange offices. Restaurants, retail shops, schools and faculties, and petrol stations are also positively related to crimes against property. The strongest correlation with violent crimes was found with petrol stations, gyms and recreation centres, and banks and exchange offices. Restaurants, bus stops, schools and faculties, and casinos and bets also significantly correlated to higher rates of violent crime. The results are in line with those of similar studies (Bernasco, Block 2011; SooHyun, Lee 2016), but there are facilities, such as cafés and clubs, that had no relationship with crime. The routine activity approach (Cohen, Felson 1979) is relevant when analysing crime counts around environmental facilities such as banks and exchange offices, gyms and recreation centres, or restaurants. The everyday activities and pathways in modern life gather a lot of people, who interact with each other, making a greater chance for both violent crime and crimes against property to occur. Also, the rational choice perspective (Cornish, Clarke 1986), which highlights the offender's choice to commit a crime, is recognisable in the analysis of crime and facilities such as retail shops and bus stops.

This study has some limitations. Firstly, there are issues with the data. Police records do not include unreported events, and this type of data is influenced by current priorities and politics. Also, crime data from the police records was not georeferenced, so it had to be geocoded. This process leads to a greater possibility of errors in locating the criminal events, but it cannot be solved unless police records report exact x and y coordinates of criminal events. Therefore, it is the researchers' responsibility to do their best to avoid such errors while processing the data. Secondly, the geodata of facilities was extracted from Google Earth. This is an unusual method for gathering data, but the data were not available from other (city or other nongovernmental) sources. Thirdly, social disorganisation factors are not included in the analysis. Therefore, future research should use these parameters to examine the influence of land use on crime.

The results of this study are important from a scientific and practical perspective. Although there is a study on spatial patterns of crime (Stanković, 2020), there are no similar spatial analyses of crime and its phenomenology and causality in Serbia. This study is among the first to use this kind of methodology and geocoding of a large set of crime data in this region. Therefore, the author hopes this research will motivate further research in the field of spatial and environmental criminology in Serbia and the Balkans. Such studies would have an impact on the development of criminology in these regions and provide evidence for practical policies. From a practical standpoint, the paper may encourage evidence-based criminal policies like the ones established in Europe and North America. The results may be valuable for different organisations in the prevention of crime. For example, the police could plan their patrol routes using maps and spatio-statistical analyses of crime. City officials could use the results in the making of urban plans, and members of local communities could become more aware of high-risk places in order to avoid victimisation.

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