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Spatial Patterns and Formation Mechanisms of Theft Crimes in the Main Urban Area of Kunming

Wang Xudan[1,a,*]

[1]*Faculty of Geography, Yunnan Normal University, Kunming, 650500, China*
[a]*2243206000133@ynnu.edu.cn*
**Corresponding author*

Abstract: *Based on 2018 theft-case data from China Judgments Online, this paper investigates the spatial patterns and formation mechanisms of theft crimes in Kunming's main urban area. Combining GIS spatial analysis and crime-geography theories, this study adopts Average Nearest Neighbor, Kernel Density Estimation and Buffer analysis to explore crime distribution and driving forces. The results show that theft cases present significant spatial clustering across the study area, with an R value of 0.393 and Z-score of -34.953. Hot-spots are concentrated along major urban roads within mixed "commerce-government-residence" zones dominated by core-service POIs. Dense pedestrian flows, complex social-spatial environments, extended crime-opportunity windows and hot-spot self-reinforcement jointly promote the aggregation of theft incidents. This research highlights that mixed-function neighbourhoods are key zones for security governance. It provides empirical evidence for refined urban anti-theft governance and rational spatial allocation of police and surveillance resources in western Chinese provincial capitals.*

Keywords: *Theft Crime, Spatial Pattern, Gis Spatial Analysis, Formation Mechanism, Main Urban Area of Kunming*

1. Introduction

Theft is the most prevalent property crime in China and places substantial pressure on social security governance. As an important sub-field of crime geography, urban crime-space research employs GIS techniques alongside routine-activity theory, rational-choice theory, and social-disorganization theory to identify spatial crime patterns and hot-spots and inform urban security management.

Internationally, the research lineage of crime geography has expanded continuously since the 1980s, grounded in the human-ecology theory of the Chicago School. Through empirical research examining the linkage between urban slums and crime rates, the Chicago School depicted crime distribution features across different zones under the "concentric-zone model", which laid a solid theoretical groundwork for follow-up studies. Scholars came to realize that geographical space is far from a passive container; instead, it actively mediates criminal events via the physical built environment, varying spatial accessibility, and social interaction networks. This spatial turn redirected crime-related research: academic attention gradually shifted from macro-scale national and regional comparisons toward micro-level units including urban blocks, communities and building-adjacent spaces, achieving a notable scale transition described as "from millions of people to millions of square meters".

Methodologically, a new paradigm combining computer-aided mapping and spatial statistics has taken shape. Early scholars adopted ArcGIS to produce crime-density maps and pinpoint high-risk crime hot-spots using spatial autocorrelation analysis, converting abstract crime regularities into readable spatial visualizations. Three cornerstone theories evolved concurrently: crime-pattern theory, social-disorganization theory and routine-activity theory. Crime-pattern theory unpacks how offenders' activity paths intersect with potential victim targets; social-disorganization theory elaborates on how eroding community cohesion elevates crime risks; routine-activity theory illustrates the dynamic spatiotemporal interplay among motivated offenders, suitable targets, and capable guardians. Together, they form the core analytical framework of crime geography and facilitate deeper understanding of formative mechanisms of criminal phenomena from a spatiotemporal-coupling perspective.

Benefiting from GIS and POI big data, existing domestic studies have achieved progress in hot-spot

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mapping, risk assessment and police resource allocation, while growing attention has been paid to spatiotemporal crime behaviors[1]. Nevertheless, empirical research on theft crimes at the micro-road scale is still scarce for provincial capitals in Southwest China[2]. Taking the main urban area of Kunming as the research case, this paper identifies theft hot-spots and explores their underlying formation mechanisms based on case records retrieved from China Judgments Online. It aims to enrich empirical evidence for crime-geography research in western China and provide support for refined local security governance.

2. Theoretical Basis And Research Design

2.1. Theoretical Principle

Proposed by Cohen and Felson in 1979, routine activity theory posits that crime occurs only when three elements converge: a motivated offender, a suitable target, and the absence of a capable guardian[3]. A motivated offender refers to an individual with the motivation and capacity to commit a crime. A suitable target denotes an object of certain value that is vulnerable to victimization; attributes such as value, accessibility, visibility and ease of transport affect the likelihood of it being targeted for crime. Capable guardians include not only formal agents of social control such as police officers and security guards, but also informal ones like mutual surveillance among community residents and neighbors. Criminal acts are likely to take place when these three elements intersect at a specific time and location.

As one of the key theories in criminology research, rational choice theory holds that offenders are rational actors who weigh the costs and benefits before committing crimes. The theory assumes that offenders evaluate potential rewards (e.g., financial gains and material satisfaction) and risks (e.g., arrest, legal punishment and damage to social reputation) based on available information when making decisions. On this basis, they decide whether to commit a crime, as well as what type of crime to perpetrate and where to commit it.

Social disorganization theory reveals the structural causes behind the concentration of theft offenses in certain areas from a macro perspective. It argues that social disorganization emerges when key components of social structure such as community cohesion, traditional values and social control mechanisms are damaged or weakened, which in turn leads to higher crime rates.

2.2. Data and Study Area

2.2.1. Data Sources

Affected by the quality of judicial document uploads in the post-pandemic period, the year 2018 with complete data quality was selected as the research period. Data were retrieved from China Judgments Online with the following filters: criminal case type, theft under crimes against property, jurisdiction and courts located in Kunming, Yunnan Province, and judgments rendered in 2018. After preliminary retrieval and manual sorting, invalid records with missing information and vague addresses were excluded. A total of 1,382 valid theft cases suitable for spatial analysis were obtained, containing key information including crime time, detailed locations, offense characteristics, and basic profiles of offenders.

Base map datasets include: road network data of Kunming's main urban area, POI (Point of Interest) data of commercial facilities within the main urban area, and administrative boundary maps of Kunming.

2.2.2. Study Area

This paper takes the main urban area of Kunming as the study area, which covers an area of 500.54 km² and serves as the core area of urban functions in Kunming. Bordering Dianchi Lake to the southwest, this area is geographically constrained by mountains in the north and west. The delineation of this scope refers to the definition of the main urban area in the Kunming Urban Master Plan (2011–2020), with the administrative boundaries of sub-districts or communities adopted as the criterion for defining the study area boundary[4](Figure 1). Most theft crime points are concentrated in the central zone, while those in the peripheral areas are mainly distributed along major roads.

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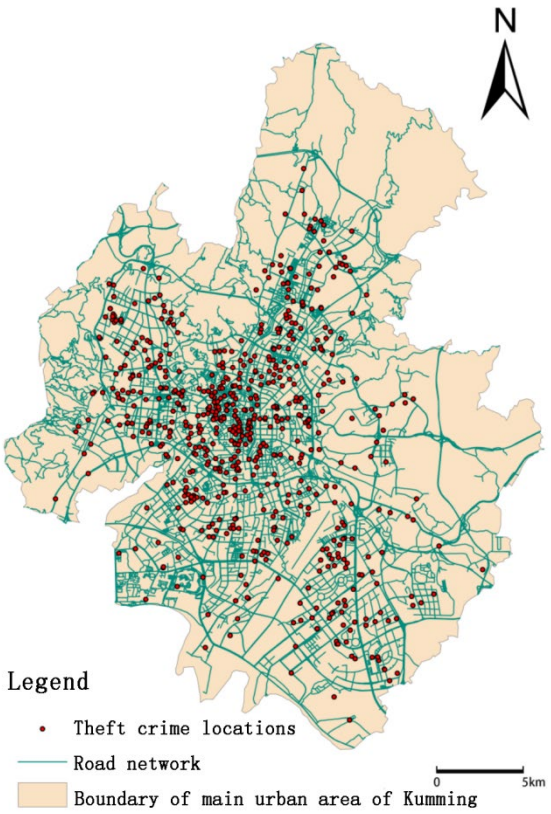


Figure 1 Scope of the main urban area of Kunming and distribution of theft-crime sites

2.3. Research Technique

2.3.1. Average Nearest Neighbor Analysis

The average nearest neighbor method is adopted to judge whether crime cases show uniform, clustered or random distribution. The ratio R is defined as (d_i refers to the observed mean nearest neighbor distance and d_e refers to the expected mean nearest neighbor distance):

$$R = d_i/d_e \tag{1}$$

In this formula, the expected value of the nearest neighbor distance d_e can be calculated using the following equation:

$$d_e = \frac{1}{2\sqrt{\frac{N}{A}}} \tag{2}$$

In this formula, N denotes the number of theft cases, and A represents the area of the main urban district of Kunming City.

When R <1, it indicates that theft cases are clustered in distribution; when R> 1, it indicates that theft cases are dispersed in distribution; when the measured value equals the expected value—i.e., when R = 1—it indicates that theft cases are randomly distributed. R falls within the range of 0≤R≤2.149, and its Z-score is defined as:

$$Z = \frac{(d_i - d_e)\sqrt{N^2/A}}{0.26136} \tag{3}$$

Wherein a lower Z-score indicates strong clustering, while a higher Z-score indicates strong dispersion; the smaller the p-value, the higher the statistical significance. The two-tailed critical Z values of 2.58, 1.96, and 1.65 correspond to p-values of 0.01, 0.05, and 0.1, respectively. If p<0.01, the spatial distribution of theft cases presents strong clustering (dispersion); if 0.01<p<0.05, the

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distribution shows moderate clustering (dispersion); if 0.05<p<0.1, it exhibits general clustering (dispersion); if p>0.1, the result lacks statistical significance, suggesting a random distribution[5].

2.3.2. Kernel Density Analysis

The kernel density estimation method can be applied to the detection of spatial hot-spots. In two-dimensional space, the general form of the kernel density function can be expressed as:

$$\lambda(s) = \sum_{l=1}^{n} \frac{1}{\pi r^2} \varphi(d_{ls}/r) \tag{4}$$

In this formula, $\lambda(s)$ denotes the kernel density estimate at location s; r represents the bandwidth, i.e., the search radius for the kernel density function; n is the number of samples; and φ is the weight associated with the distance d between the theft case and location s .

2.3.3. Buffer Method

The areas within a radius of 100 m, 300 m, and 800 m around each case location are designated as the Core Coverage Area, General Coverage Area, and Peripheral Coverage Area, respectively. The theft case coverage rate R can be expressed as:

$$R_c = \frac{A_c}{A - A_0} \times 100\% \tag{5}$$

In this formula, A represents the total area of the study area, while A_0 represents the area corresponding to the service type within the study area. A higher value of R_c indicates a higher spatial coverage rate of theft-crime incidents.

3. Spatial Distribution Characteristics of Theft-Related Criminal Cases

3.1. Overall Distribution Characteristics

The results of the average nearest neighbor analysis show that the mean nearest neighbor distance is 718.1454 m, the R value is 0.393, and the Z-score is -34.953. This indicates that theft cases in the main urban area of Kunming exhibit strong spatial clustering. The core coverage area of theft cases (100 m radius) totals 18.11 km², with a coverage rate of 3.61%; the general coverage area (300 m radius) is 95.15 km², corresponding to a coverage rate of 19.00%; and the peripheral coverage area (800 m radius) is 197.35 km², with a coverage rate of 39.43%. Its spatial coverage pattern (Figure 2(a)) reveals that the buffer zones overlap heavily in the central part of the main urban area and form continuous coverage regions. This is fully consistent with the conclusion of "significant clustered distribution" derived from the preceding average nearest neighbor analysis, demonstrating that theft offenses do not occur in isolation but form stable crime hot-spots in specific zones.

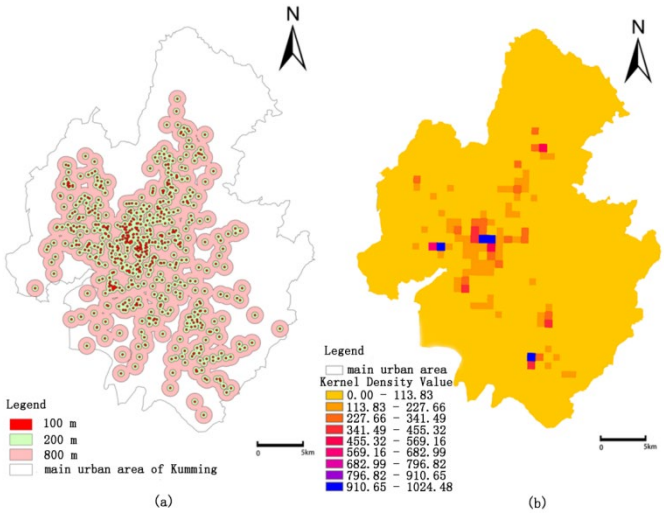


Figure 2 Buffer-zone coverage and kernel-density distribution of theft-crime sites. (a) Buffer-zone coverage of theft-crime sites; (b) Kernel-density distribution of theft-crime sites.

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The kernel density function (with a search radius set to 150 m) was adopted to explore the spatial pattern and hot-spots of theft cases in Kunming's main urban area (Figure 2(b)).The top 10 roads ranked by the number of crime points are listed (Table 1). The figure illustrates that theft hot-spots are largely concentrated in the central urban district. It suggests that the spatial pattern of theft offenses can partly reflect the mixing and complexity of urban functional zones and serve as a vital indicator of regional social security conditions. Investigating spatial disparities in theft offenses enables a partial understanding of the spatial variations in social security within Kunming's main urban area.

Table 1 Top 10 roads ranked by the number of crime points

Road Name	Number of Crime Points	Data Source
Wuyi Road	42	China Judgements Online, GIS statistical tools
Yunxiu Road	42	China Judgements Online, GIS statistical tools
Liyuan Road	37	China Judgements Online, GIS statistical tools
Dongsi Street	23	China Judgements Online, GIS statistical tools
West Panlong Road	21	China Judgements Online, GIS statistical tools
North Xiyuan Road	21	China Judgements Online, GIS statistical tools
Yangjia Road	20	China Judgements Online, GIS statistical tools
Yulong Road	20	China Judgements Online, GIS statistical tools
Baiyun Road	16	China Judgements Online, GIS statistical tools
Longquan Road	16	China Judgements Online, GIS statistical tools

3.2. Road Micro-Level Analysis

Based on the Kunming road network data and POI (Point of Interest) information, a micro-level analysis can be conducted on the top ten roads; the categories of these POIs are listed in Table 2, among which shops offering science, education, and cultural services, as well as shopping services, account for the largest proportion.

Table 2 Statistics of POI categories

Store Type	Count	Percentage
Science, education and cultural services	9937	15.4%
Shopping services	9595	14.8%
Government agencies and social organizations	7735	12.0%
Commercial residences	6616	10.2%
Life services	4880	7.5%
Corporations & enterprises	3817	5.9%
Medical and health services	3751	5.8%
Accommodation services	3384	5.2%
Catering services	3150	4.9%
Sports and leisure services	2927	4.5%
Public facilities	2876	4.4%
Financial and insurance services	2416	3.7%
Automobile services	1735	2.7%
Automobile sales	922	1.4%
Scenic spots	464	0.7%
Automobile maintenance	440	0.7%
Road auxiliary facilities	53	<0.1%
Transportation facility services	2	<0.1%
Motorcycle services	2	<0.1%
Indoor facilities	1	<0.1%

The common characteristics of theft-concentrated areas can be inferred from the types of stores along each road:

First, POIs of core services dominate these areas.

Second, Governmental and residential POIs are widely present.

Third, Life-supporting POIs are generally distributed.

Fourth, Professional service POIs account for a relatively low proportion.

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3.3. Formation Mechanism Analysis

(1) Dense pedestrian flow and exposed property. Commercial shopping streets and catering districts have heavy foot traffic. Pedestrians carry valuables such as mobile phones and wallets, and the mixed crowds create opportunities for pick-pocketing and bag theft.

(2) Complex spatial and social environments. Hot-spot roads lie within mixed commercial, residential and administrative neighbourhoods. Permanent residents, office workers and floating consumers are highly intermixed. Numerous spatial entrances and exits provide offenders with routes for committing crimes and escaping, raising the difficulty of security management. Pedestrian gathering points such as bus stops further amplify such risks.

(3) Formation of crime opportunity windows. Shopping and catering businesses maintain long opening hours, generating continuous pedestrian flow throughout the day and extending the temporal window for crime. Surveillance blind spots exist in some areas, and public vigilance declines amid crowded conditions, collectively creating criminal opportunities.

(4) Self-reinforcement of crime hot-spots. Hot-spots with high success rates continuously attract offenders. If local security facilities are not upgraded simultaneously, crime will persist at a high level, forming a vicious cycle.

4. Discussion

This study finds that theft hot-spots in western-China provincial capitals tend to cluster in old-town renewal blocks and mixed-function neighborhoods, differing from eastern cities where hot-spots concentrate in central business districts[6]. Methodologically, this study combines buffer and average-nearest-neighbor analyses to improve crime identification at the micro-road scale. Practically, mixed-function zones should be prioritized for security governance to optimize the deployment of police and surveillance resources[7].

This study has several limitations. First, it only uses 2018 records from China Judgments Online, whose data coverage has inherent uncertainties. Second, as cross-sectional data are applied, temporal variations of theft across day-night cycles, holidays and seasons cannot be captured, failing to reflect space-time hot-spot evolution. Third, road-based analysis overlooks within-block micro-environmental disparities including building layouts and community governance, which may conceal intra-road crime heterogeneity.

Future work could incorporate mobile-phone signaling and public-transport big data to build space-time crime models. Research outputs can inform urban-renewal planning, and multi-city comparisons across Southwest China may help generalize regional crime spatial patterns.

5. Conclusion

(1) From the perspective of spatial pattern, theft crimes exhibit prominent spatial clustering. Such offenses show strong agglomeration characteristics. The central urban area, together with the buffer zones in the northwest, presents substantial overlap, forming crime hot-spots centered on roads including Wuyi Road and Yunxiu Road.

(2) In terms of spatial morphology, this clustering pattern is closely associated with the mixed allocation of urban functions. On the one hand, core service facilities dominate hot-spot areas. On the other hand, governmental and residential functions are widely distributed within these zones. Together, they constitute a highly compound spatial structure of “commerce-government-residence”. The mixing of urban functions, to a certain extent, promotes the spatial agglomeration of theft crimes.

(3) Multiple mechanisms drive crime occurrence. First, mixed functions bring dense pedestrian flows and raise the exposure of property. Second, complex functional combinations increase the difficulty of environmental supervision. Third, round-the-clock operating venues extend the crime opportunity window in the temporal dimension. The superposition of these factors creates a hard-to-break vicious cycle.

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