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Assessing temporal and weather influences on property crime in Beijing, China

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Abstract Though the relationships between environment and crime have been studied a lot in many countries, this work is still a void in China. This work presents the study about how property crimes are influenced by the temporal and weather factors in China. With the crime data collected from police, the property crimes pattern by season of year, day of week and time of day are investigated firstly. Then the influence of the temporal variables—major holidays, school close days and weekends—and weather on the crimes are tested. The findings show that the robbery is significantly influenced by the temporal variables but has no correlations with weather, while burglary is not only affected by the temporal variables but also correlated with sun light hours.

Introduction

The relationship between environment and crime had been widely recognized and researched [7–11, 14, 16, 21], but little is known about how temporal and weather variations influence the crime patterns in China. In this article, there are several reasons for doing this research. First, most work about crime pattern research mainly focused on developed countries, very few work were devoted to the developing countries. Though Vânia Ceccato assessed how Homicide varied by space and time in Brazil [3], the country's political regime is different from that in China. As the largest developing and socialism country in the world, China has its unique political regime and justice system. Many crimes in China have different definitions or classifications from those in other countries. So, studying the crime patterns in China will be interesting and maybe a complementary to the crime research.

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Second, as people with different culture background, Chinese has its unique lifestyles and habits which make them form into particular routine activities. So, it is quite possible that this difference in culture has an effect on how, when and where Chinese interactions occur.

As the capital of China, Beijing is the prime metropolitan area in north of China and one of the most populated cities in the world. More than fifteen million people live in the city in 2007. Among them, about one quarter is floating population that coming from the other areas of China.[1] Meanwhile, Beijing is challenged with the serious problem of crime. During the years between 2004 and 2005, more than 50, 000 property offending incidents were reported to the Police, which indicated that about 140 robbery, burglary or theft occurred per day. So, thirdly, assessing crime patterns by time might reveal some regulations of crime and offer prevention suggestions for the police.

This paper collected some crime data from the Police in Beijing and made study about how property offending patterns varied by time and how they were influenced by the temporal and weather factors. The structure of this article was organized as follows. Section "Literature review" briefly reviews the previous research in the field of crime and how it was influenced by weather and temporal variations. Then next, summary about Beijing city and crime data quality is presented. Section "Crime pattern analysis and modeling" demonstrates the results of the crime pattern analysis and modeling. Then in the end, summarizations and the main conclusions are given.

Literature review

Empirical works

The work on how property crime was related with environment could be dated back to the 19th century. In the work named '*Sur L'Homme, et Le Dévelopment de ses Facultés*', Quetelet noted that crimes against property occurred most frequently in the winter and the crimes against person occurred most frequently in summer. In 1908, Hugo Herz made statistic analysis about crime in Austria and found that crime against property peaks in autumn and winter months. Then in 1917, Von Mayr discovered that offenses against property in Germany reach maximum in December and minimum in April [13]. Lately, as more crime recordings and meteorological data were available, the work on how property crime was related with weather was investigated widely [7–10, 16, 18, 21]. More weather variables, such as ambient temperature, wind speed, relative humidity, fog, precipitation, sunlight, barometer pressure, cloud coverage, lunar, et al were considered as the independent variable. For example, Cohn discovered that temperature emerged as a significant predictor of theft, burglary and robbery when she made analysis about crime recordings in US [10], while Lab found that humidity has the most predictive power to the property offenses [18].

Comparing to the influence of weather on crime, the research about how crime varies by temporal variables emerged later but was studied more [3, 7–12, 15–18, 21]. Cohn examined the data of calls for police service in Minneapolis in US and

[1] According to the Beijing Area Statistic Yearbook, in 2007, the total population in Beijing was 15 810 000, floating population was 3 830 000.

found that robbery and burglary showed different patterns by time of day and day of week [10]. Additionally, Henry and Bryan studied motor vehicle theft in Adelaide in Australia and they found the crime did not only vary by time of day and day of week, but also by month of the year [17]. Recently, holidays and exceptional events were considered as the extra temporal variables. Cohn and Rotton tested the crime's variation on major holidays and minor holidays in America, and they found that both the violent and property crimes had significantly relationships with major holidays (New Year's Day, President's Day, Memorial Day, Independence Day, etc), while neither type of crime was more likely to occur on minor holidays [11]. In 2007, Decker, et al. made an investigation about the 'routine' crime which was measured by calls for police service, official crime reports and police arrests in Salt Lake City before, during and after the 2002 Olympic Games [12]. They considered that since lots of people came to Salt Lake City during the Olympic, residential routine activities were inevitably affected, so the crime rate would be influenced. Their work suggested that the minor crime increased in Salt Lake during the Olympic Games period, which shows that the patterns of crime would vary when exceptional events took place.

Theories

Besides the empirical work that focusing on the relationship between environment and crime, several theories were proposed to explain how weather and temporal variables influence crime patterns. The theories usually make the explanations from two ways: individual and event. Initially when people investigated the crime's variation by season of the year, a number of sociological and psychological factors were proposed to interpret these general trends. For instance, Quetelet suggested that '*in winter, misery and want are more especially felt, and cause an increase of the number of crimes against property*' [13].

Recently, two theoretical models, Negative Affect Escape (NAE) model [2] and General Affect (GA) model [1] were proposed to explain the aggressive crimes from psychological aspect. The NAE model stated that in some conditions such as extremely high or low temperature, the negative effects of environment on people increase, and then it leads to the aggressive and escape motives increase. Both increases might cause different outcomes. For example, in condition of high negative effect levels, if the escape motives overcome the aggression motives the escape is probably expressed as the main behaviors; otherwise, if escape motives is not as powerful as aggression motives, more aggression behaviors would emerge in uncomfortable situation. So, in this way, the environment brings conflict influence to people. On the other side, GA model which was proposed by theorists suggested an idea that in some weather conditions as extreme temperature probably facilitate affective aggression, and these aggressions has its primary purpose that injuring other person. But however these models try to correlate environment with aggressions from theoretical aspect, they concentrated more on crimes against people but had little power explanations to property crime. Cohn had made comments on the theories, '*any aggression that may be involved in property crimes is mainly instrumental; it is directed against another person merely as a means to an end, with the incentive generally being to obtain the property of that person*' [10].

Comparing to NAE model and GA model, routine activity (RA) model is a different theory. It focused more on event rather than personality. As a theory that

assessing environmental influence on crime indirectly, RA theory suggested that individual's activities and daily habits are rhythmic and consisting of patterns that were always repeated [6], then the changing of the environment may result in variations of behaviors and activities [7]. According to RA theory, most crimes depend on the interactions of three elements in space and time: motivated offenders, suitable targets and capable of guardians against crime. For the motivated offenders, they usually choose the best opportunities to make offences, but whether the offenders could be on the right time and right place depend on the intersections of suitable targets and capable guardians. The targets and guardians are not necessary person or police, but could be the empty houses or the person on the present. Drawing on the work of human ecology, [6] believed that performed routine activities were under the influence of environment, so the crime risk in space and time would be indirectly affected by the varied weather or temporal condition [10]. For example, when weather turns better or holidays come, people are inclined to spend more time outdoors, and this behavior will cause property crimes to occur in two ways. First, the likelihood that potential offenders and victims come to contact will increase, thus the property crimes as theft and robbery are facilitated; second, the people would like to leave their house during good weather and holiday, thus the risk of burglary will be higher on those days. The RA theory is a useful tool in describing crime patterns' variation and it had been used to explain temporal and cross-sectional variations in several property crimes [4, 5].

Summary about Beijing and crime data quality

In this section, the summary introduction to Beijing was given. In first part, a simple description of Beijing society was given, and next, the definitions of crime and quality of the property crime data used in this paper were discussed.

Summary about Beijing

Beijing lies on the northern of North China plain and southern of Yanshan Mountain (latitude: 39°28' S~41°05' S, longitude: 105°24'~117°30'). The climate in Beijing is a typical warm temperature semi-humid continental monsoon. Summers are hot and rainy, winters are cold and dry, spring and autumn is short. The annual average temperature is about 10°C or 12°C. In January, it is −7°C to −4°C, extreme minimum could be −27.4°C. In July it is 25°C to 26°C, extreme maximum is 42°C or more. The annual average rainfall is more than 600 mm, but the distribution is very uneven. Seventy-five percent of the rainfall concentrates in summer, especially in July and August.

As the city that had been the capital for more than 600 years and concentrates numerous natural and history sites, Beijing attracted lots of people for traveling and visiting. Every year, on major holidays and school vacations, there would be many visitors and travelers in Beijing. So, on those days the roads, stations and airports were much crowed. But for the local residents, they had different lifestyles on holidays. Because most people in Beijing had to work very hard in order to survive in the city, they seldom had time to be on vacation. Therefore, on holidays, they

prefer to stay at home for rest rather than go out for traveling. Besides, the crowed population on holidays prevents them from traveling.

Crime definitions and data quality

The property crime in China doesn't have exact definitions. In general the illegal acts offended for property targets could be thought as property crime. Currently, the widely accepted property offences by people include robbery, burglary, fraud, theft and blackmail. As a country with unique justice system, China's crime definitions are different from the other countries. For example, in United States the robbery is thought as a violent crime, however in China, robbery is considered as a property crime, because according to People Republic of China Penal Code[2] the robbery is defined as '*to obtain properties by means of violence*' (art 236). So, whatever the means the offender used, the crime would be classified into property crime if the final target of the offenders is to obtain property. The case is the same to the burglary. In China, burglary is described as the crime that '*illegal entry other's home with intention of occupying properties*', which is different from the countries that acquire '*breaking and entering*' as the necessary elements of burglary.

The crime data in this study originated from Beijing 110, which is an automated database system operated by Beijing Municipal Public Safety Bureau. This system is an important resource of collecting crime information, because in China once people have trouble they would call 110 instantly for police help. The troubles are not necessary serious offence, but could be minor troubles in life, such as getting lost in avenues. But even in this way the actual crime level is still underestimated, and the underestimated level is different for various type of crime. Quite often the victims who suffer from house property aggression would like to make the calls, while the victims who suffer from body aggression were reluctant to call 110. For example, according to the Victimization survey in 1994, only 19% victims suffer from theft in Beijing would like to call 110 for help [20].

The offered crime data was the first hand 2 years recordings from 110 database system (2004–2005). The recordings include a lot of crime's information, but only robbery and burglary were selected to be studied. The reasons for that are various. First, robbery and burglary are the two major threatens in property crimes, not only in Beijing, but all over China. Based on descriptive statistic of crime rate series from 1978–2002, the mean level of burglary was 138.23 per 100, 000 people and the robbery was 8.94 per 100,000 people. Both crimes were the two most serious property offences in this period [19]. In this way, the analysis of robbery and burglary is significant to the prevention and suppression of property crime. Second, the robbery and burglary recordings provide plenty data for research. In the crime data, the proportion of robbery and burglary in all property crime recordings is as much as 80%. In this way, there are not plenty crime data available for the other property offences analysis.

Basically, the crime data has numerous attributes which help make the pattern analysis. They include time of day, day of the year and type of the offences. The

[2] The newest edition was promulgated in 14 March, 1997. Available at http://www.law-lib.com/law/law_view.asp?id=327

crime data was processed firstly before analysis was made. The problems of data that may cause analysis wrongly were mainly duplicate recordings and missing data. Sometimes the crimes may be reported both by the victims and witnesses, so repeated recordings were caused. Besides, for unknown reasons some recordings lost important information such as time and crime type. All the duplicate and missing recordings were eliminated from the database. The bad data only make up less than 1% of total recordings, so the quality of the data in this study was good.

Temporal variables were created based on available calendars, and weather data was downloaded from web site of Central Meteorological Station of China. All the weather data are free to obtain.

Crime pattern analysis and modeling

Crime pattern by temporal variables

In this section, property crime's variation by different time was demonstrated. The differences in levels of robbery and burglary by season of year were tested using one-way ANOVA with a post doc Scheffe test (Table 1). The results showed that the difference of robbery by season of year didn't exist (F=1.735). But for burglary, the difference was significant (F=25.563). The levels of burglary in winter differed from the ones found for the hot months of the year (summer and autumn). The average of burglary by day increased from 117.94 in summer to 134.02 in winter, about 13 burglary incidents per day.

By time of day, most robbery incidents were reported during the period between 06:00 PM and 06:00 AM. As much as 75% of all robbery incidents were reported to Police at this time (Fig. 1). Particularly around midnight (11:00 PM–01:00 AM) the number of robbery reporting reached a peak, which was identical to prior work [15]. The distribution of robbery by time of day illustrated that robbery mainly concentrated at night. While as to burglary, it showed a different pattern. Most burglary incidents occurred between 05:00 AM and 11:00 PM. In such a period as much as 90.8% burglary were reported (Fig. 2). Particularly around time 07:00 AM–10:00 AM, burglary reported to the Police reached a peak. The distribution of burglary by time of day showed that this offense mainly concentrated at day and evening time, and morning was the crime window.

Table 1 Difference in robbery and burglary by season, 2004–2005

	Robbery mean	F-test	Burglary mean	F-test
Spring (1)	15.57	1.735	111.94	25.563[a]
Summer (2)	15.90		117.31	
Autumn (3)	15.55		123.57	
Winter (4)	14.52		134.02	

[a] Significant at 99% level

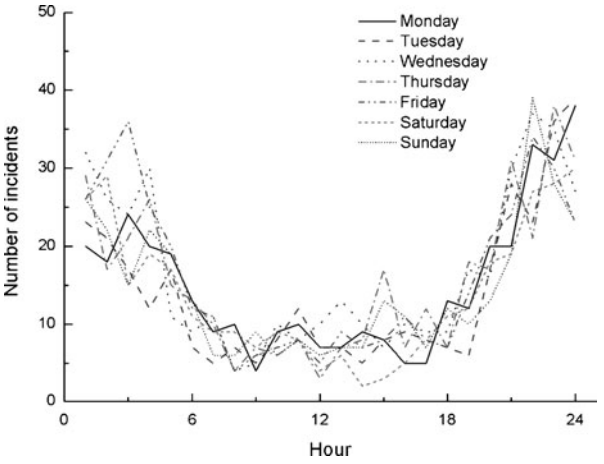

Fig. 1 Number of robbery incidents by hour of day, 2004–2005, Beijing

According to the curves in graphs, the distributions of robbery and burglary by hour of day from Monday to Sunday were approximately identical according to Figs. 1 and 2. Actually, for people who live in Beijing, at weekends they usually have different lifestyles from workdays, so it was possible that crime pattern in weekend was different from workdays. The differences between workdays and weekend for robbery and burglary were tested with Independent-Samples T Test. As Table 2 showed, the difference between workdays and weekends for robbery was insignificant (t=0.926), but for burglary, the result was significant (t=2.091). The average burglary level decreased from 61.44 on workday to 59.13 on weekends, which indicated that burglaries on weekend were more inclined to be suppressed by people's routine activities.

Crime patterns by weather variables

The relationship between weather variables and property crime in Beijing was investigated. Four weather variables—ambient temperature, wind speed, sun light

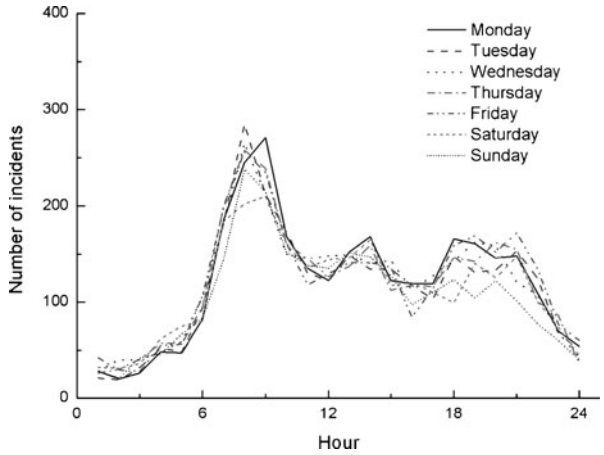

Fig. 2 Number of burglary incidents by hour of day, 2004–2005, Beijing

Table 2 Difference in robbery and burglary between weekdays and weekends, 2004–2005

	Robbery mean	*t*-test	Burglary mean	*t*-test
Week (1)	7.75	0.926	61.44	2.091[a]
Weekend (2)	7.52		59.13	

[a] Significant at 95% level

and humidity—were obtained from website of Central Meteorological Station of China and all of them are the values averaged by day.

The relationships between weather variables and property crimes were plotted in graphs (Figs. 3, 4, 5, and 6). The findings showed that robbery and burglary have similar patterns in the function of weather variables. For ambient temperature, most robbery and burglary incidents concentrated in the range of −7°C to 27°C (91.2% for robbery; 91.1% for burglary), and they both increased as temperature rised. The slope was 0.18 for robbery and 1.85 for burglary (untransformed logarithmically). When ambient temperature exceeded 27°C, either robbery or burglary decreased as temperature rise further.

While for the other three weather variables, the curves showed that crime level varies obviously by weather variables. For example, 93.1% robbery and 93.3% burglary incidents occurred in condition that wind speed less than 4 m/s; 60.0% robbery and 61.6% burglary incidents took place in the condition that sun light hours between 6 and 12; 76.4% robbery and 75.9% burglary incidents occurred when relative humidity was larger than 15% and less than 85%. These findings indicated that robbery and burglary were more inclined to occur in a comfortable circumstance, but quite few occurred in extreme weather.

Modeling robbery and burglary in Beijing

In this part, the influence of weather and temporal on robbery and burglary were tested with regression analysis (Ordinary Least Squares). The series of robbery and

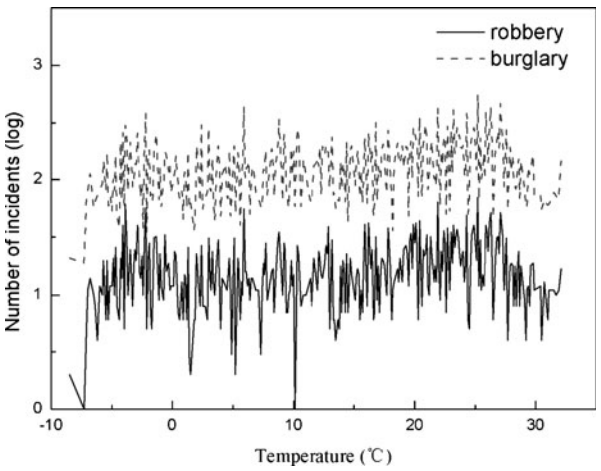

Fig. 3 The relationship between property and average temperature (°C)

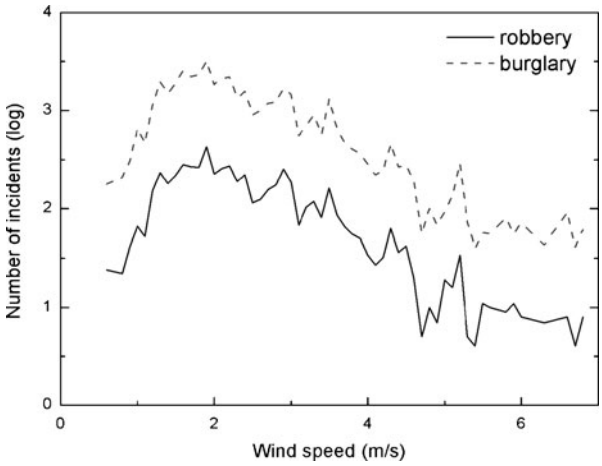

Fig. 4 The relationship between property and wind speed (m/s)

burglary were treated as the dependent variables, the weather (e.g. temperature, humidity, sun lights, wind speed) and temporal (e.g. weekend, major holidays, school close days) variables were treated as explanatory variables. "Appendix A" showed the variables definitions, data sources and explanations of the coding process used in the analysis.

In the model, robbery and burglary data was aggregated into groups by day (N= 731). Pearson correlation analysis was made to test if a relationship exists between the explanation variables. The results were shown in "Appendix B". It is found that humidity was significant correlating with temperature, sun lights and wind speed. So, humidity was eliminated from the independent variables list. The final independent variables in the regression model included weekends, major holidays, school close days, wind speed, temperature and sun lights.

The OLS was run in the econometric software EVIEWS 6.0. The outcomes were shown in Table 3. The findings showed the R^2 was 0.10 for robbery and 0.538 for

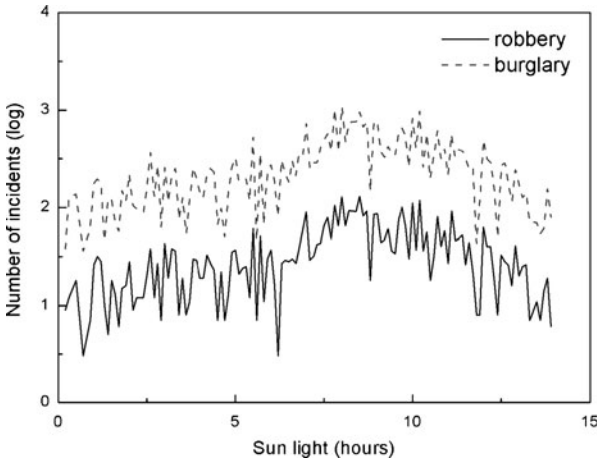

Fig. 5 The relationship between property and sun light (hours)

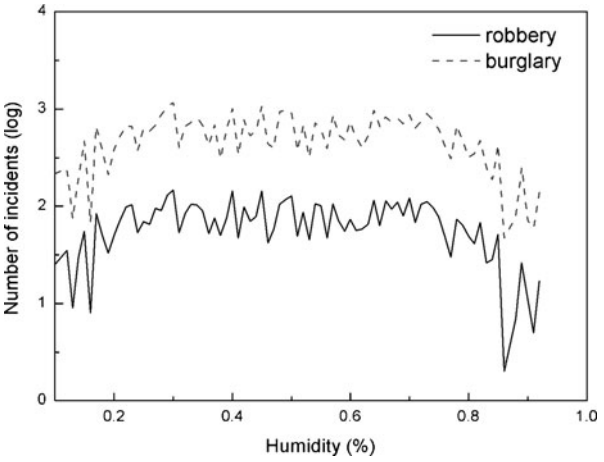

Fig. 6 The relationship between property and humidity (%)

burglary. The *t*-tests showed that all coefficients in regression equations were all significant at the level of 1%.

According to the results, it could be seen that robbery was significantly influenced by temporal variables of major holidays and school close days, but had no correlations with weather variables. The coefficients of the regression indicated that robbery would occur less frequently on holidays and school close days, which was identical to the findings of previous work [10]. But as to the burglary, the regression results demonstrated that the crime was not only influenced by the temporal variables, but also correlated with the sun lights, and the coefficients of the variables showed that burglary would occur less frequently on holidays, school close days and weekends, but increased on the days when weather was good.

Table 3 Results of regression analysis, China, 2004–2005

Robbery	6.92	−1.43 Holiday[a]	−0.87 SchoolCloseDay[a]	
	(25.27)	(−2.91)	(−2.92)	
	t-values in brackets			
	$R^2 \times 100 = 10.0\%$			
	R^2(adjusted)×100%=9.5%			
	F-statistic=20.1, $p<0.01$			
Burglary	49.22	+ 0.037 Lineartrend[a]	−6.51 Holiday[a]	−4.27 SchoolCloseDay[a]
	(35.88)	(12.85)	(−3.0)	(−2.94)
	−2.68 Weekends[a]	+ 1.04 Sun light[a]		
	(−3.42)	(2.99)		
	t-values in brackets			
	$R^2 \times 100 = 53.8\%$			
	R^2(adjusted)×100%=53.5%			
	F-statistic=140.7, $p<0.01$			

[a] Significant at 1% level

The findings of the regression analysis revealed that property crime in Beijing was influenced significantly by the people's routine activities. Because on holidays and school close days, lots of people would come to Beijing for traveling, so on these days the stations, airports, museums, parks and interesting sites would be much crowed. The people around these places played the role of informal guardians and then prevent the offenders committing robbery effectively. But for the local residents, they usually prefer to stay at home rather than go out for enjoyment because there were so many people outdoors. So, on holidays, school close days plus weekends, the homes were defended by the owners well and the potential burglaries were prevented effectively.

Sunlight was the only weather variable that significantly influencing burglary. Cohn suggested a negative relationship between the sunlight and the occurrence of a domestic violence or rape event, because '*the darkness produces the feeling of anonymity, reduces inhibitions and isolates the aggressor from the victim*' [8]. But for burglary, this result could be explained by the routine activities theory. On pleasant weather, people are more likely to have their activities outdoors, so the likelihood of house being offended by burglars increased.

Conclusion

This work made the analysis about how property crimes in Beijing were influenced by temporal and weather variables and concluded several findings. First, by investigating the patterns of robbery and burglary by season of year, day of week and time of day, it was found that robbery and burglary have different crime window. For robbery, the crimes were more reported at night, especially around the midnight. But for burglary, the crimes usually occurred at daytime. Additionally, burglary also showed the patterns that varying by season of year and day of week, but robbery didn't. Second, the relationships between property crimes and weather variables showed that few robbery and burglary occur in condition of extreme weather. Third, the regression analysis that assessing how temporal and weather variables influence on property crime indicated both robbery and burglary would occur less frequently on major holidays and school close days, but burglary would increase on the days with more sun light hours, which showed that crime patterns in Beijing were influenced by routine activities of people.

Though the information and data for analysis were very limited, this paper still made some work about how crime patterns vary by temporal and weather variables, and the results might offer some help for crime prevention and analysis for the police. Considering the culture difference between northern and southern of China, the people in these areas may show different routine activities. So collecting more crime data from different cities (Shanghai, Guangzhou, etc) of China and continuing to explore crime patterns in other places will be our future work.

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Appendix A

Table 4 Description of the data set

Variables	Descriptions
1.Crime variables	Call for police service of robbery and burglary from January 1, 2004, to December 31, 2005
	Source: computer aided dispatching (CAD), Beijing Municipal Public Security Bureau
2.Temporal variables	Season of the year (linear trend variable)
	*Dummy for major holidays (1 = Labor's day, National day, New Year's Eve, Spring Festival, 0 = otherwise)
	*Dummy for weekend (1 = Saturday, Sunday, 0 = otherwise)
	*Dummy for school closed days (1 = January 16, 2004 to February 15,2004; July 10, 2004 to August 31, 2004; January 22, 2005 to February 20,2005; July 10, 2005 to August 31, 2005, 0 = otherwise)
3.Weather variables	Temperature (°C) from January 1, 2004, to December 31, 2005
	Wind speed (m/s)
	Sun light (hours)
	Source: web site of Central Meteorological Station of China (http://cdc.cma.gov.cn/shuju/index.jsp?tpcat=SURF)
	Station: 54511

Appendix B

Table 5 Pearson correlation coefficients among weather variables (two-tail test)

	Temperature	Humidity	Wind speed	Sunlight
Temperature	1	0.378[a]	−0.159[a]	0.090[a]
Humidity		1	−0.509[a]	−0.590[a]
Wind speed			1	0.259[a]
Sunlight				1

[a] Significant level 0.01

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