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The Mapping of Spatial Patterns of Violent Crime in Peninsular Malaysia: Normal Mixture Model Approach

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ABSTRACT

The objective of this study was to explore the geographic distribution and temporal patterns of violent crime cases in Peninsular Malaysia by using the tools and techniques for spatial analysis. This study will also provide a general picture of violent crime patterns in Malaysia. The unit of analysis is district and the violent crime data from the year 2000 until 2009 were used in this study. In order to obtain the optimum number of components of crime in the space-time period, the space-time Normal Mixture Models were used. Based on the results of this model, the mapping of the crime occurrences was made. This map displays the spatial distribution of crime occurrence in 82 districts of Peninsular Malaysia. From this analysis, more violent crimes were shown to have occurred in developed states such as Selangor, Wilayah Persekutuan Kuala Lumpur and Johor. The findings of this study could be used by policy makers or responsible agencies to take any relevant actions in terms of crime prevention, human resource allocation and law enforcement so as to overcome this important issue in future.

Keywords: Violent crime, normal mixture, model mapping

INTRODUCTION

Crime is one of the major problems faced by most countries in the world. The most common indicator used to measure crime cases is the crime rate. The pattern of this social problem can be detected differently based on specific types of environment. Crime is believed to be higher in the more developed and densely populated areas such as at large cities, towns or urban areas compared with undeveloped areas such as the rural areas. This situation happens because of several factors such as environmental characteristic, economic, social, political, demographics, and so forth. The results of a study by Gyamfi (2002) parallel this theory. The author reported that crime was highest in

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southern Ghana, where it is the more developed and densely populated region. In addition, crime cases increased from the northern to southern Ghana, with a heavy concentration in Ashanti, the most populous region. Savoie *et al*. (2006) also found that property crimes highly happened in the city centre of the Island of Montreal. Meanwhile, Perreault *et al*. (2008) found that youth crime is distributed over many small hot spots across the entire island of Montreal. Crime situation was also found to be affected by global economic situation (Sidhu, 2005). During an economic downturn or recession, unemployment rate rises and people face difficulty finding jobs. This scenario will increase crime rates. The labour market conditions are also believed to have links with crimes. This association was studied by Lee and Slack (2008), who found that an index of low hour and seasonal employment had negative relationship with crime rates.

Recently, the opportunities for using social science data (i.e., crime data, disease data, accident data) to estimate spatial patterns and relationships increase because of the rapid development in the tools and methods in the field of spatial analysis. Spatial analysis is a method that is widely used to study issues related to space, place, or geographical circumstances. In spatial analysis, the location where an event occurs may provide an indication of the reason why that particular event occurs. In the beginning, spatial analysis involves mapping methods, reviews, and geographic location without formal techniques.

At the beginning of 21st century, spatial modern analyses were widely developed and focused on specific use of computer-based techniques. Mapping is one of the most widely used techniques in spatial analysis. It is very useful especially in identifying the relationship between exposure and the cases concerned. Later, spatial analysis becomes more widely used in many areas. It is not only used by researchers in the field of geography but also applied in many fields of study such as epidemiology (Forand *et al*., 2002; Kandala *et al*., 2006), biology, demography (Osei & Duker, 2008), health (Gatrell *et al*., 2004; Holt & Lo, 2008; Waller &Gotway, 2004), sociology, statistics, information technology, safety (Erdogan, 2009; Erdogan *et al*., 2008), Mathematics (Kakamu *et al*., 2008), Science and Computer Science (Corcoran *et al*., 2007).

The traditional mapping method frequently used is the percentile method. However, the classification based on percentile is arbitrary because it cannot be confirmed if this classification is able to detect high-risk or low-risk areas properly.Analternative method that can be used for classifying the risk of each study area using the mixture model (Bohning & Seidel, 2003; Schlattmann & Böhning, 1993; Schlattmann, 2003). Based on the simulation study carried out by Böhning and Schlattman (1993), that aimed to compare the mapping based on the percentile method with mixture model methods,found that the mixture model approach provided a high percentage of correct classification than the traditional methods.

In crime study, combinations of theoretical and statistical analyses are believed to be very useful. A study by Ackerman and Murray (2004) used this combination to study on assessing the spatial patterns of crime cases in Lima, Ohio, by using geographical information systems (GIS) and quantitative techniques. They analyzed the violent and property crimes at the macro, meso, and micro levels. Apart from that, several studies also investigated the impacts of factors on crime cases, while suggestions for strategic planning to overcome the problems were also provided. For example, Kanyo and Norizan (2007) studied the trend of crimes by investigating the factors that are believed to have significant effects on the crime cases in Penang, Malaysia. They also provided several suggestions related to the actions that could be taken to overcome crime problems. Meanwhile, Felson and Poulsen (2003) studied the simple indicators of crime by the hour in 13 middle-sized American cities by using robbery data for 1999 to 2001. However, these studies were analyzed without taking into consideration the spatial effects. The analyses of crime cases by using spatial technique are growing from time to time. Rogerson and Sun (2001) analyzed the geographic patterns of crimes using the spatial method by combining nearest neighbour statistic and cumulative sum method. They described a new procedure for detecting changes over time in the spatial pattern of crime point events in Buffulo, New York. Collins *et al*. (2006) examined the basic theory and methods used to analyze the spatial lattice data and applied the method in the crime cases analysis. In their study, they used two forms of simultaneous autoregressive model known as spatial lag and spatial error model. Other studies by Ackerman and Murray (2004) used geographic information system, GIS and quantitative techniques to explore spatial characteristic of crimes. Meanwhile, Gyamfi (2002) examined the socio spatial environment factors that might have significant effects on macro geographic crime trends and patterns in Ghana.

Problems due to crimes have also become a major concern for policy makers in Malaysia. This situation can be seen from crime data given by Royal Malaysia Police (PDRM). These problems will cause not only the loss of property, lives, and misery, but also large impacts on many aspects such as psychological, economical and so on. Sidhu (2005) and Sidhu (2006) reported that crime trends developed from simple crimes which became more complex global crimes. This situation makes the work more difficult, especially for police department to detect and solve the crime cases reported by the public.

In Malaysia, limited studies have been done on crime data using statistical method. Most of the studies done focused more on experts' opinion or knowledge and discussed about the causes and effects of crimes, such as the studies by Kanyo and Norizan (2007), Sidhu (2005) and Sidhu (2006). The investigation of the crime situation can be more significant using a combination of qualitative and quantitative techniques. The objective of this study was to explore the geographic distribution and temporal patterns of violent crime cases in Malaysia using the Normal Mixture Model approach. This study is hoped to provide a general picture of the violent crime patterns in Malaysia.

RESEARCH HIGHLIGHTS

1. Instead of using commonly used of crime rates based on population, this study uses crime rates based on the total number of crimes.
2. The optimum number of components of space-time mixture model for crime data from 2000 to 2009 is five.
3. Application mixture model produce smoother map compared to traditional methods.

DATA

Malaysia comprises two major parts known as Peninsular Malaysia and East Malaysia. Based on the 2000 census, Malaysia is divided into 14 states, 82 administrative districts in Peninsular Malaysia and 53 administrative districts in East Malaysia. Due to the difficulty in obtaining data in East Malaysia, this study only included districts in Peninsular Malaysia. In this study, administrative district was used as the unit of analysis. There are twelve states located in Peninsular Malaysia, consisting of a total of 82 districts.

The number of crime cases employed in this study was obtained from Royal Malaysia Police (PDRM). Two categories of crime cases were included in index crime statistics known as violent and property crimes. The definition of index crime statistics is the crimes that are reported with sufficient regularity and with sufficient significance to be meaningful as an index to the crime situation (Sidhu, 2005). It is important to note that this study only considered violent crimes.

The violent category includes murder, gang robbery with firearm, gang robbery without firearm, robbery with firearm, robbery without firearm, rape, and voluntarily causing hurt. The data from 2000 to 2009, according to each district reported in Peninsular Malaysia, were analyzed in this study.

Violent crime rate (vr) standardized by total crime cases is defined as the total number of violent crime divided by the total number of crime, T. Then, the value of rate takes a logarithmic transformation. This transformation ensures that the variables are on the same scale. The values of the log of rate, x_i follows approximately normal distribution that takes any real number (Ceccato & Dolmen, 2011; Cole, 2009; Collins, Babyak & Moloney, n.d.; Wang, 2005). Further analyses are implemented by using statistical techniques based on assumption of normal distribution. The formula for rate of violent crime is given as follows:

$$VR = \frac{V}{T}$$

where

V is the number of an event occurred and is the total number of crimes occurred. In this study, event is referred to the number of violent crime cases and T is the number of violent crime coupled with property crime cases. Instead of the common rate known as crime rate based on population at risk, this rate is used as an alternative solution for the small number problem (Waller & Gotway, 2004). Rates based on the small populations with small numbers of violent crime cases will be high than the rate based on large populations with small number of violent crime cases. Let say, there are two district with 100,000 population and 1000 population. These two districts recorded the same number of violent crime cases, which is 45. The rate is 0.00045 for the first district and the rate for the second district is 0.045. The rates do not reflect the true risks based on the crime incidents.

METHODOLOGY

Mixture Model of Normal Distribution

The mixture model assumes that the population under study comes from a certain distribution but it consists of components with different levels of risk incidence, which then becomes a heterogenous case (Lindsay, 1995; Rattanasiri, Böhning, Rojanavipart & Athipanyakom, 2004). Each component follows a normal distribution with mean, $\hat{u}_k$ and standard deviation, $\hat{\sigma}_k$, and represents a certain proportion, $\hat{p}_k$, of the total district unit.

As suggested by Everitt and Hand (1981), the parameter estimate is done by using Maximum Likelihood Estimation (MLE). The probability density functions for vector random variable, x, of dimension *n* have the following form:

$$f(x;p,\sigma,\mu)=\sum_{k=1}^{c} p_k g_k(x;\sigma_k,\mu_k) \tag{1}$$

In equation (1), $p=(p_1,p_2,...,p_{c-1})$ are the $c-1$ independent mixing proportions of the mixture where

$$0<p_k<1 \quad \text{and} \quad p_c=1-\sum_{k-1}^{c-1} p_k \ , \tag{2}$$

with μ_k and σ_k as the mean and standard deviation vector, respectively. The log of the likelihood function is given by:

$$L=\sum_{i=1}^{n}\log_e\{\sum_{k=1}^{c} p_k g_k(x_i;\sigma_k,\mu_k)\} \ . \tag{3}$$

The maximum likelihood equations are obtained by equating the first partial derivatives of (3) with respect to p_k, the elements of each σ_k, and those of each vector, μ_k, to zero.

Let the probability of observations x_i belong to the component *s* denoted by $P\left(s|x_i\right)$, where

$$P\left(s|x_i\right)=\frac{p_s g_s\left(x_i;\sigma_s,\mu_s\right)}{f\left(x_i;p,\sigma,\mu\right)} \tag{4}$$

Using equation (4), the estimated value of parameters are given in the following form:

$$\hat{p}_k=\frac{1}{n}\sum_{i=1}^{n}\hat{P}(k|x_i) \quad \text{where} \quad \begin{cases} p_k, & k=1,...,c-1 \\ 1-\sum_{1}^{c-1} p_k, & k=c \end{cases} \tag{5}$$

$$\hat{\mu}_k=\frac{1}{n\hat{p}_k}\sum_{i=1}^{n}\hat{P}(k|x_i) \quad \text{where} \quad k=1,...,c \tag{6}$$

$$\hat{\sigma}_k=\frac{1}{n\hat{p}_k}\sum_{i=1}^{n}\hat{P}(k|x_i)\left(x_i-\hat{\mu}_k\right)^2 \quad \text{where} \quad k=1,...,c \tag{7}$$

The next step after parameter estimation is to determine the optimum number of components that are compatible with the data. This can be done by computing Likelihood Ratio Statistic (LRS) for testing the hypothesis:

H_0 : number of components = k

against

H_a : number of components = k + 1

The likelihood ratio test is defined as

$$LRS = -2 \times [L_k - L_{k+1}],$$

where L_k is the maximum likelihood estimator under the null hypothesis and L_{k+1} is the maximum likelihood estimator under the alternative hypothesis. The LRS test has an asymptotic null distribution χ^2 of with degree of freedom equal to the difference number of parameters under the null and alternative hypothesis. However, McLachlan (1987) reported that the regularity conditions of conventional LRS result do not hold for this distribution. In order to solve this problem, several previous studies have proposed a method known as parametric bootstrap to obtain a critical value. McLachlan (1987) and Shlattmann and Bohning (1993) have provided more details on bootstrap procedure.

By applying parametric bootstrap, B bootstrap samples are generated randomly from the mixture density $f(x;p,\sigma,\mu)$ of the original sample based on the number of components under the null hypothesis. In this study, a total bootstrap samples of 200 replications were generated. Parameter estimation using the MLE method was applied for the null and alternative hypotheses for each bootstrap sample. Then, the value of LRS was computed for these bootstrap samples to get the B replicated values of LRS. Hence, the distribution of LRS under the null hypothesis is assessed. Hypothesis testing of the null hypothesis versus alternative hypothesis was tested with a bootstrapped critical value and compared with the LRS value from the original sample.

Space Time Mixture Modelling

The basic idea of space-time mixture model technique was to consider the space-time data as one dataset which consists of data combination for several years. Let be the violent crime rate for area i, i, $i = 1,...,n$ and time t, $t = 1,...,T$, the mixture probability density of normal distribution is defined as:

$$f(x;p,\sigma,\mu) = \sum_{k=1}^{c} p_k g_k(x_{it};\sigma_k,\mu_k) \qquad (8)$$

where

$$0 < p_k < 1 \qquad p_c = 1 - \sum_{k-1}^{c-1} p_k \ .$$

The log of the likelihood function is given by

$$L = \sum_{t=1}^{T} \sum_{i=1}^{n} \log_e \{ \sum_{k=1}^{c} p_k g_k (x_{it}; p, \sigma_k, \mu_k) \} \quad . \tag{9}$$

The maximum likelihood equations were obtained by equating the first partial derivatives of (3.8) with respect to p_k , the elements of each matrix σ_k and those of each vector μ_k , to zero. One advantage of using the space-time mixture model is that it provides fewer parameters for comparison (Rattanasiri *et al*., 2004). For example, in this study, only 1 set of parameters was estimated instead of 10 sets of the parameters that were needed to be estimated for the mixture model applied separately for each year of the study period. For the purpose of computational simplicity, this study assumed that all components have the same standard deviation ($\sigma_1 = \sigma_2 = ... = \sigma_c$).

RESULTS AND DISCUSSION

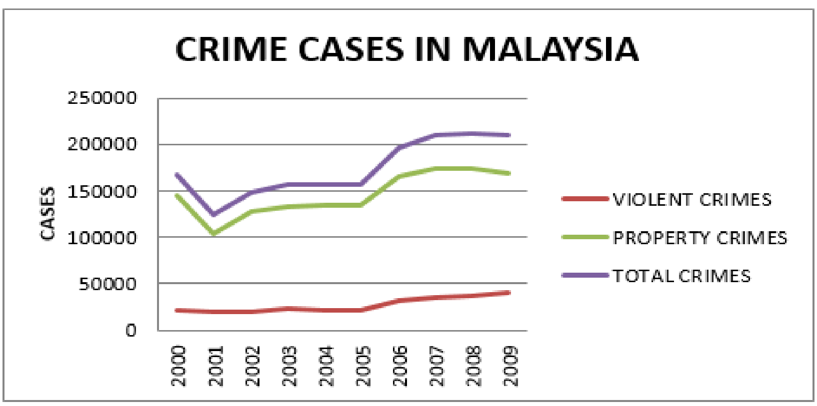

Fig.1: Crime cases in Malaysia, 2000 - 2009

As a preliminary analysis, Fig.1 shows the line graph of crime cases in Malaysia from 2000 to 2009. It shows that the violent crime cases remained along the same gradual growth from 2000 to 2005. However, the crime incidents were slightly higher from 2005 to 2009. On the other hand, the property crime cases showed fluctuation trends throughout the study period. From year 2000 to 2001 and between 2008 and 2009, the property crime cases showed a downward trend, whereas for 2002 to 2007, it showed an upward trend. The figure also showed that the property crime cases were the main contributor to the total crimes since the patterns of this crime were very similar to the pattern of the total crime cases. Throughout the study period, there were increases of 88.9% in violent crimes and 15.9% in property crimes as compared to 2000 to 2009. Although the number of cases for violent crime was less than the number of cases for property crimes, violent crimes grew at a faster rate than property crimes.That was one ofthe reasons why only the analysis of violent crime was discussed in this study. Overall, the total crime cases increased about 25.3% from 2000 to 2009.

For further analysis, the normal space-time mixture model as discussed in the methodology section was be applied to violent crime data in Peninsular Malaysia from 2000 to 2009. This space time method has made comparisons of the map much easier because it has the same scale, whereby each year has the same number of components and parameter estimates. On the contrary, a separate mixture model gives different numbers of the component for each year with different parameter estimates. This is rather arbitrary that has made map comparison difficult to do. For illustration purposes, Table 1 shows the results of the estimated parameters value for the space-time mixture model for data of 2000 to 2009.

TABLE 1 : Result of fitting space time mixture model to violent crime rate (from 2000 to 2009)

Component	Proportion, p	Log Mean, μ	Mean	Standard Deviation, σ	Log Likelihood, L	LRS , $-2(L_k - L_{k+1})$
k=7	0.1036113	-0.9825961		0.7343305	-543.9397	
	0.146502	-1.16606		0.6774542		
	0.1619918	-1.173779		0.5938236		
	0.1655543	-1.15195		0.5237591		
	0.1610484	-1.112987		0.4557219		
	0.1494789	-1.060338		0.3917262		
	0.1118132	-0.9064786		0.2710334		
k=6	0.1263943	-1.016897		0.7384063	-543.5343	-0.810929
	0.1762872	-1.175104		0.6527572		
	0.1917415	-1.168136		0.5613894		
	0.1910558	-1.131699		0.4786827		
	0.1788031	-1.076412		0.4055494		
	0.135718	-0.9255937		0.2802739		
k=5	0.159318	-1.05329	0.348788	0.7292025	-542.6071	-1.854387
	0.2189217	-1.181914	0.306691	0.6220058		
	0.2311252	-1.155231	0.314984	0.5163202		
	0.2200448	-1.09602	0.334199	0.4206643		
	0.1705903	-0.9487246	0.387235	0.291106		
k=4	0.2107838	-1.09205		0.7218557	-540.9602	-3.293775
	0.2824057	-1.181832		0.573576		
	0.2822723	-1.124204		0.4497419		
	0.2245381	-0.9774026		0.3041401		
k=3	0.3011373	-1.140015		0.6958411	-537.3221	-7.276182
	0.3810857	-1.167653		0.4984847		
	0.3177769	-1.013429		0.3199025		
k=2	0.4727242	-1.194746		0.4700092	-675.598	276.5518
	0.5272758	-1.100158		0.3820215		
k=1	1	-1.150677		0.4213953	-680.0797	8.963265

The main question arising in this analysis is whether the risk of crimes for each district in the study area is homogeneous or not. If the risk is homogeneous, the number of components is one. The hypothesis testing to test k=1 against k=2 is done. From the table, it can be seen that the improvement in log-likelihood model with two components is quite large. Thus, the two-component modelis better than a model with only one component. Large improvement was also found in the log-likelihood value when the number of components is 3 and 4. However, the log-likelihood improvement showed a small difference between the model with 4 components and the model with 5 components.

The first hypothesis tested the number of components k = 4 against k = 5. From the bootstrapped result, the 95% confidence interval of LRS distribution is (-2.828311, 1.53165). Meanwhile, the value of LRS from the original sample is -3.293775. The value of LRS from the original sample is not in the confident interval. Therefore, there is sufficient evidence to reject the null hypothesis.

The second hypothesis tested the hypothesis of k = 5 against k = 6. From the bootstrapped result, it was found that the 95% confidence interval of LRS distribution is (-2.289859, 0.9772211). The value of LRS for the original sample is -1.854387, which means that the value falls within the confidence interval. Therefore, there is no evidence to reject the null hypothesis. Since the null hypothesis cannot be rejected, the optimum number of components of space-time mixture model for crime data from 2000 to 2009 is five.

For the application of the mixture model to the space time period of 2000-2009, the optimum number of categories obtained was five components. The first component has a mean of 0.348788 [exp (-1.05329)] and standard deviation of 0.729202. This means, 0.3487 of 1 total crime is violent crime. In other words,there were approximately 4 cases of violent crime occur every 10 criminal cases. For this space time period, 15.9% of the districts were allocated in the first component, 21.9%, 23.1%, 22.0%, and 17.1% in the next category, respectively.There are more districts included in thecomponent with lower violent crime rates for components 2, 3 and 4 compared to components 1and 5 with have high crime rates.

The map was constructed based on the mean of violent crime rates where the darker areas have higher crime rates. From the map, we can see the changes of crime occurrence for each district. For illustration purposes, four maps for 2001, 2003, 2006 and 2009 were provided. For example, from Fig.2, the darkest area shave the rate of 0.387235 while the most promising areas have a mean rate of 0.306691. Whereas for every 10 cases of total crimes that have occurred, approximately 4.0 cases of violent crimes occur in the riskier areas.

As shown in Fig.2 to Fig.5, the number of districts with higher mean (shown by darker colour on the map) increased from 2001 until 2009. The obvious changes can be seen at the area of southern Peninsular Malaysia. For 2001, 2003 and 2006, it showed that no district in that area fell within the components with the highest crime rates. However, almost all the districts in the south fell into the category with the highest crime rates in 2009. The same scenario also happened in the state of Selangor, whereby more districtswere in the categories with high crime rate values in 2009 compared to the previous years. A similar situation occurred in Wilayah Persekutuan Kuala Lumpur which fell within the component with the highest crime rates in 2009.

This situation is believed to be attributed by the unemployment rate in Malaysia. For example, the unemployment rate in Johor in 2006 was 2.1%, and this rate increased to 3.2% in 2009. Meanwhile,the unemployment rates of unemployment in Selangor in 2001, 2003, 2006 and 2009 were 2.4%, 3.2%, 3.2% and 3.6%, respectively. It can be seen that the violent crime rate is affected by unemployment rate. When the unemployment rate increased, violent crime rate will also increase. This factor was discussed in this study because it is the common factor which had mostly been considered inprevious studies (see Amar & Sidhu, 2005, 2006; Andresen, 2012; Baller, Anselin, Messner & Hawkins, 2001; Ceccato & Dolmen, 2011; Kakamu, Polasek & Wago, 2008; Lee & Slack, 2008; Tsushima, 1996). However, a detail analysis should be done to check for the significant relationship between violent crime rates and the unemployment rate using a statistical analysis such as by using the spatial modelling.

Based on the map of the four-year study, there were three districts in the category with the highest crime rates, namely, Gua Musang, Sepang and Cameron Highland for all the four years. Meanwhile, most districts of the state of Johor were in the category of low crime rates in 2001, although these districts were in the riskiest category of crime rates in 2009 such as Segamat, Kluang, Mersing, Kota Tinggi, Johor Bharu, Pontian, Muar and Batu Pahat. Meanwhile, some other areas that were categorised in the less risky category in 2001 were found to be in the highest crime rates category in 2009. The districts are Manjung, Hilir Perak, Seremban, Tampin and Port Dickson.

It can be seen that the application ofthe mixture model to crime data by district in Peninsular Malaysia was able to produce a clearer map compared to the traditional method known as the choropleth method. It removes the random variability from the map (Rattanasiri *et al*., 2004; Schlattmann & Böhning, 1993; Schlattmann, 2003). Forexample, maps constructed based on the choropleth method, that is, quintiles (divided into 5 groups) of the crime rates from originaldata are presented in Fig.7 to Fig.10. As shown in those figures, the map based on the mixture model provides a clearer picture of the high and low risk areas.

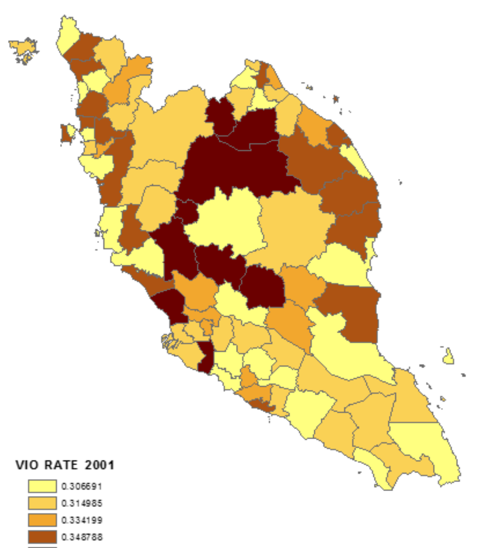

Fig.2: A map showing violent crime rate using the space-time mixture model for 2001

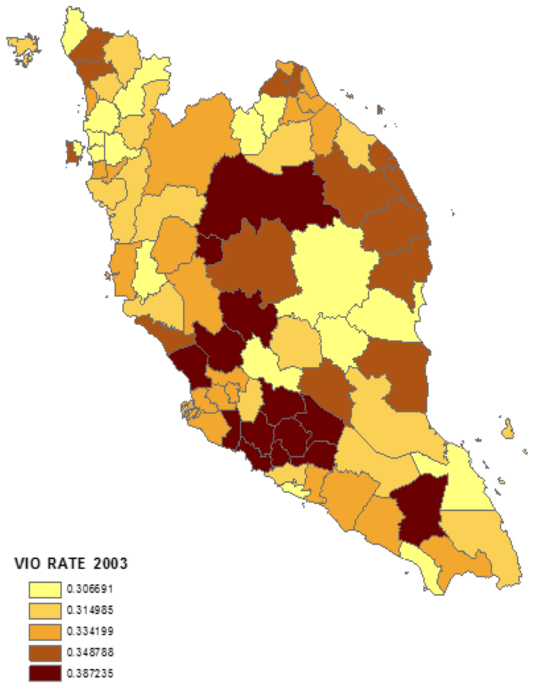

Fig.3: A map showing the violent crime rate using space-time mixture model for 2003

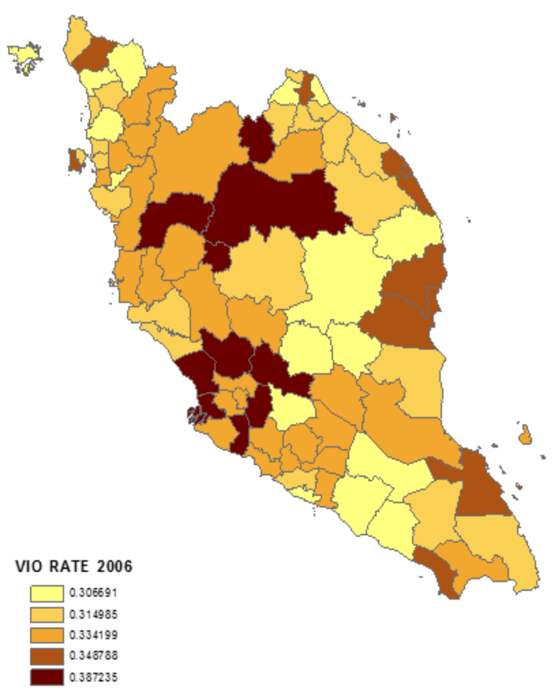

Fig.4: A map showing the violent crime rate using the space-time mixture model for 2006

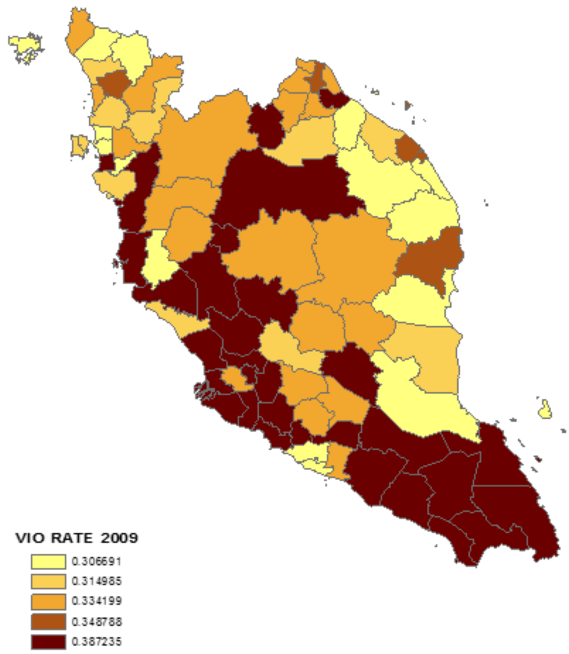

Fig.5: A map showing the violent crime rate using space-time mixture model for 2009

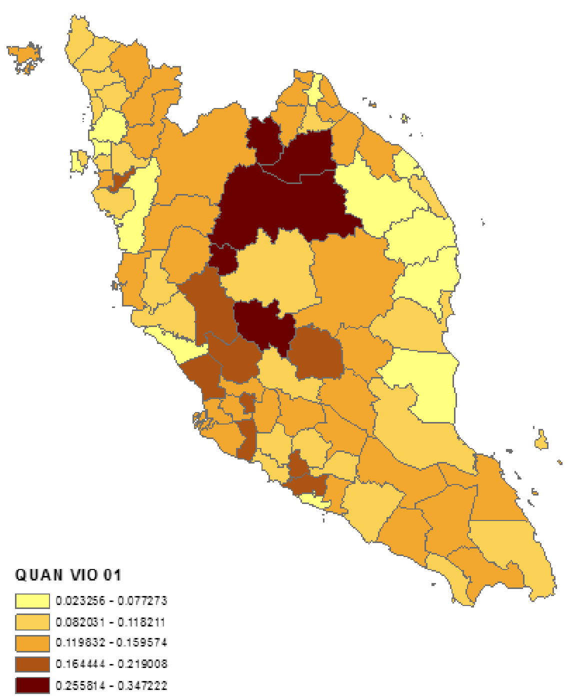

Fig.6: A map showing the violent crime rate using the percentiles method for 2001.

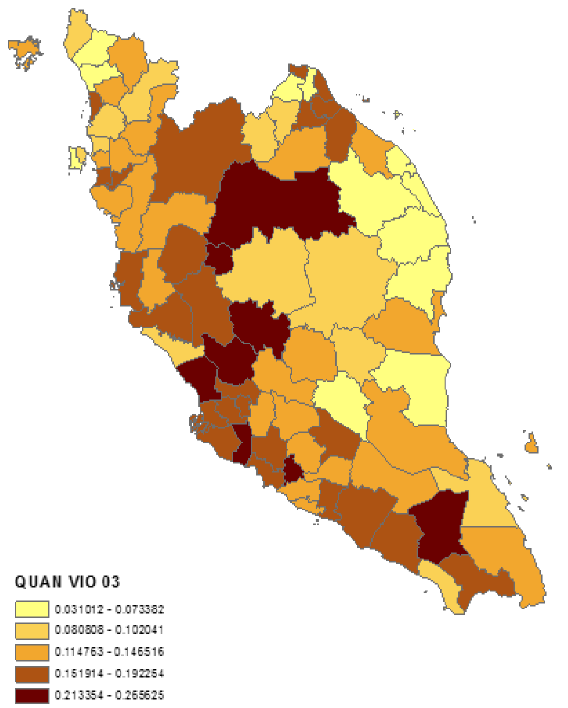

Fig.7: A map showing the violent crime rate using the percentiles method for 2003

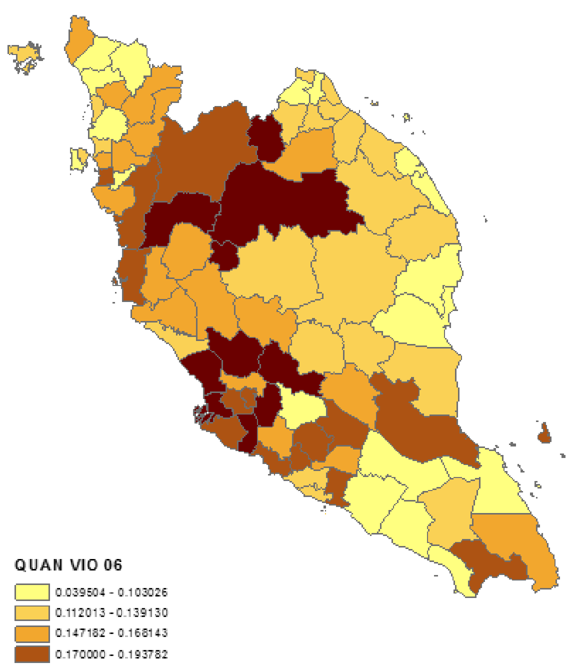

Fig.8: A map showing the violent crime rate using the percentiles method for 2006

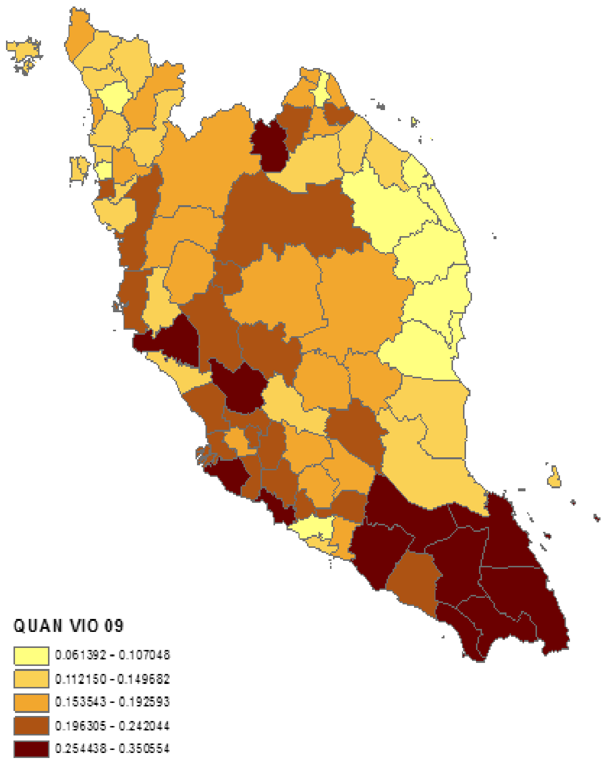

Fig.9: A map showing the violent crime rate using the percentiles method for 2009

CONCLUSION

Crime is one of the major problems faced by most countries in the world including Malaysia. This social problem causes not only losses of property, lives, and misery but also has large impacts on many aspects such as psychological, economical and so on. Mass media play an important role in the public's perception of the incident of crimes. The sensational news of crimes widely disseminated by the press and media can cause more fear amongst the public compared to the official statistics reported by the police. From this analysis, more violent crimes were found to be occurring in developed states such as Selangor, Wilayah Persekutuan Kuala Lumpur and Johor. The resultsobtained are consistent with several previous studies which reported that developed states have higher crime rates compared to developing and under developed states (Gyamfi, 2002; Savoie *et al*., 2006; Perreault *et al*., 2008).

It is impossible to provide crime forecasts with a high degree of accuracy because it is dependent upon socioeconomic, demographic and environment factors, among other. In this study, it seems that there is a relationship between violent crime rates and unemployment rates. However, for more detailed analysis, some statistical modelling should be done such as spatial regression modelling to measure the relationship between these variables. Although there is no intelligence formula that can be used to reveal future crime situations, information of the past reported crime cases can be one of the sources to predict the situation of crimes in the future.

Crime mapping is one of the methods that can be used to analyze the crime situation in a country. Based on the maps obtained, the high and low crime areas can be identified. Therefore, the authorities should pay more attention to the high crime areas so that necessary actions can be taken to overcome the crimes. The main concern is usually to reduce both crimes because they affect not only the people in particular, but also the nation in general.

It is believed that a study on the spatial and demographic patterns of crimes in Malaysia can provide useful information for the government, safety department and policymakers to make appropriate planning, especially in resource allocation and to develop suitable strategies for future plans to overcome problems pertaining to crimes. The forecast information of the future trends by using past data is a valuable tool to policy makers in developing crime prevention programmes. These outcomes can be used to target particular populations and develop interventions so that suitable actions are better adapted to the environmental and socioeconomic settings. However, well-organized data collection and computer storage are very important as these allow spatial pattern analysis over space and time to make them easier and more effective. Thus, more accurate and appropriate action plans can be done to overcome the crime situation in Malaysia.

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