Spatial Analysis of Five Crime Statistics in Turkey

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Key words: Crime rates, geographical information systems, spatial analysis.

SUMMARY

In this study, geographical information systems and explorative spatial data analysis methods were employed in the analyses of five selected crime rates. Because of the differences among the provinces with small populations, and the provinces with large populations regarding volume of crimes make a major impact on the stability of the crime rates, empirical Bayes smoothing method was used to correct the crime rates. Global spatial autocorrelation indices including Moran's I, Getis-Ord G, and Geary c were used to test the spatial dependence. Local spatial autocorrelation methods were used to detect the clustering of crime rates. The present study demonstrates the utility of spatial analyses for exploring crime levels of the five crime statistics in Turkish provinces.

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1. INTRODUCTION

Criminal activities are important concerns in the public safety of a contemporary society. Today many countries are faced with high levels of offences and crime rates. Clarifying where different types of crime and other incidents occur is one of the many important functions of crime analyses. There are different types of crime analysis. Many of the researches and practices are oriented to tactical, strategic, and investigative types of crime analysis. The aims of these applications are to detect the distribution and clustering of crimes, and to identify high rate regions to implement precautionary measures and provisions by crime agencies for public security (Mostafa, 2003). However, administrative type of crime analysis focuses on providing summary data, statistic, and general trend information to managers. This type of analyses interest with the study of crime and law enforcement information integrated with socio-demographic and spatial factors to determine long-term patterns of activity to assist problem solving.

Macro-level crime mapping studies that fall within administrative type of crime analysis have advanced knowledge of how crime is distributed over large areas with the availability of crime data for the public. Crime mapping is the key concept in these analyses to understand the spatial and temporal occurrence of crime, but it is only the first step. The next step is the usage of geographical information systems (GIS) and spatial statistics to detect the spatial-temporal clustering of crime patterns for proper social and criminal precautionary measures. Advances in the field of information system technology over the last 30 years have provided powerful abilities. Therefore, GIS have been begun to use to measure and represent the spatial relationships in the data in crime analyses and prevention programs. GIS aided spatial analyses identify the crime patterns and suggest reasons for crime characteristics.

Empirical examples of spatial analysis of crimes are mainly concerned with black spot analysis in the cities. With a few exceptions, regional data are often neglected (Cracolici and Uberti, 2008; Neapolitan, 1998).

Regional variations in crimes in Turkey have also received no attention so far, although Turkey has large regional differences in socio-economic development. Turkey, a rapidly developing country, is a junction point between Asia and Europe in terms of its social demographic and economic structure. The analysis of crime in economic and quantitative terms has received attention only in the last years. However, there is not a research on geographical distribution of crimes by using GIS and spatial analysis. This paper examines the regional disparities hidden behind national statistics on some crime statistics in Turkey with GIS and spatial analyses.

It is a common practice to compare cities or countries in terms of safety performance, and to rank them in terms of risk indicators such as the crime rates, which are often expressed as the number of crime per 100000 persons. In this paper, five kinds of crime activities: theft,

swindling, battery, homicide, and crimes related with firearms and knifes against the person were examined by using exploratory spatial analysis.
Because of the availability, the data on convicts received into prison because of deprivation of freedom sanction by court is used in the analysis for the crime rates. The crime data on convicts, which are compiled from "The Statistical Form Related to Convicts Received into Prison" by mail in each month, obtained from Turkish Statistical Institute by making payment. These statistical forms have been filled in by authorized person of prison according to official records of convicts and declaration of convicts. Population by census year (2000), annual intercensal rate of increase, mid-year population forecasts have been taken from the Turkish Statistical Institute too.

2. METHODOLOGY

Aggregated area-based data are very important sources of information for many social science disciplines. Analyses of aggregated crime data are necessity for quantitative assessment of criminological theories or policy changes. Today, criminologists have been increasingly applying formal tools of spatial analyses to describe and explain variations in levels of crimes with related to the demographic, socio-economic, and functional characteristics of neighborhoods. Such analyses provide support to administrators as they determine and allocate resources to have a better understanding of the community crime and disorder problems (Murray et al., 2001). Geographical locations of the data are also an important factor in many areas of social and economic policies at national level. Province unit is common level for social, economic, demographic, and administrative data collection by agencies in Turkey. Hence, usage of province units in analyses allows comparing crime statistics. Therefore, five crime statistics are examined with spatial analyses at the province level in this study. However, province units have important limitations; provinces are administrative units, and cover large areas with different heterogeneous populations, and they might not match the ecological scale at which diffusion processes for homicide (Messner et al., 1999).
In developing countries like Turkey, political, economical and social changes occur due to migration while inadequate urban developments. In the large cities of such countries lead to problems in education, health, transportation, and employment, which are factors that increase crime rates (Yirmibesoglu et al., 2007). Keeping in mind these factors of the crime phenomenon, these aggregated crime statistics is investigated to catch important provincial disparities across time and space. Therefore, suitable tools of ESDA are used to control for possible spatial heterogeneity.
When the change in crime structure based on the years of the period of the 1997-2006 is examined, it is seen that there is a decrease in homicide rates, a significant increase in battery and assault rates, and fluctuations in swindling and theft rates. There is stability in the crimes related with firearm and knifes rates. It is taught that aggregating the crime rates for some years provides the advantage of stability in the province-level crime rates, and it summarizes the phenomenon. Hence, crime and its causal factors would be in a steady relationship throughout the time series (Messner et al., 1999). Therefore, a temporal equilibrium state is examined using time series of crime rates. According to the time series of homicide and battery rates, 1997-2001 periods emerged as relatively stable period for both rates. However,

2001-2006 periods emerged as the decreasing period for homicide rates, and increasing period for the battery rates. Theft and swindling examined year by year. Because of the determination of two different period of temporal equilibrium, spatial analyses are performed according to periods of 1997-2001 and 2002-2006.

Firstly, since the raw counts is not the best tool for inference about crime risk, using the midyear population and the number of convicts according to crime types, average raw crime rates were calculated for the each year and for the periods of 1997-2001 and 2002-2006 by provinces. However, raw crime rates may still obscure the spatial pattern in crime risk, particularly if the rates are based on populations of very different sizes. In order to overcome of the problem of rate instability, various smoothing approaches are usually employed (Anselin et al., 2006). In this study, empirical Bayes (EB) smoothing that Clayton and Kaldor (Waller et al., 2004) are proposed was used.

Furthermore, a commonly used concept in the rate analyses that is the excess risk rate was used in the determination of risky provinces. The excess risk ratio is the ratio of the observed crime rates to the average crime rates computed for the crime types. An excess risk rate greater than 1.0 indicates that more crimes occurred than would have been expected while a ratio of less than 1.0 indicates fewer crimes than expected. Excess risk maps of crimes are shown in Figure 1.

Secondly, the tests for spatial autocorrelation are used to detect the possible clustering of crime patterns. Since the crime data are aggregated into the areal units of provinces, an important aspect is deriving spatial weight matrix (W) for spatial analyses. In this study, the focus is on diffusion and spatial randomness and hence general notion of nearest neighborliness and contiguity were used to determine W.

In order to identify and measure the strength of spatial patterns, showing how the crime rates are correlated in the country, Moran's I and Geary c values are calculated with three W matrices. Moran's I and Geary's c statistics measure the deviation from the spatial randomness.

Moran's I and Geary's c methods indicate clustering of high or low values, but these methods can not distinguish between the situations. The Getis-Ord General G statistic is therefore used to give an understanding of the clustering of high or low values. The General G statistic shows either hot spots or cold spots in the region. A larger value of G statistic than expected means that high values are found together (hot spots), and a small value of G statistic means low values are found together (cold spots).

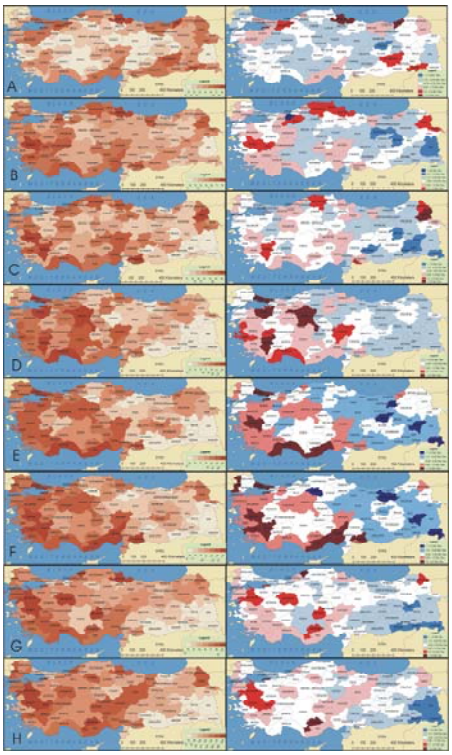

Figure 1. Maps of smoothed crime rates (left side) and excess risk rates (right side); A:Crimes related with firearms and knifes, B:Homicide rates, 1997-2001 period, C: Homicide rates 2002-2006 period, D: Swindling, E: Assault and battery 1997-2001 period, F: Assault and battery 2002-2006 period, G: Theft 1997-2001 period, H: Theft 2002-2006 period

Table 1 shows the results relative to the Moran's I, Geary c and Getis-Ord General G tests based on two different kinds of weights matrices; the contiguity matrix, and the geographical proximity matrix with 6 nearest neighbor. The choice to include different weights matrices is mostly due to the intention to distinguish contiguity geographical effects and distance based effects (Cracolici and Uberti, 2008).

Table 1. Global spatial autocorrelation analysis of raw crime rates

Crime type and period	Moran's I geographical proximity	Z score	Getis-Ord G	Z score	Geary C	Z score	Moran's I contiguity	Z score
Homicide rates 1997-2001 period	0.18	2.16	0.036	-0.16	0.93	-2.62	0.240	2.42
Homicide rates 2002-2006 period	0.27	3.19	0.037	0.68	0.88	-4.56	0.264	3.05
Swindling	0.39	4.57	0.038	1.13	0.95	-2.12	0.340	4.02
Assault and battery 1997-2001 period	0.41	4.70	0.037	0.71	0.81	-7.49	0.413	4.19
Assault and battery 2002-2006 period	0.35	4.06	0.040	0.59	0.81	-7.45	0.393	4.21
Theft 1997-2001 period	0.41	4.77	0.038	1.18	0.93	-2.56	0.390	5.03
Theft 2002-2006 period	0.47	5.46	0.038	1.27	0.94	-2.42	0.495	5.55
Crimes related with firearms and knifes	0.03	0.44	0.037	0.68	1.02	0.77	0.091	0.95

Moran's I, Getis-Ord General G and Geary c are global spatial autocorrelation indices and yield only one statistic to summarize the whole country. In other words, these global analyses assume homogeneity. However, if there is no global autocorrelation or clustering, clusters can be still found at a local level. To investigate the spatial variation as well as the spatial associations, it is possible to calculate local versions of Moran's I, and the General G statistic for each provincial unit in the crime data (Mitchell, 2005).

LISA was used as a local indicator of spatial association, which investigates those clusters of areas with similar values and those clusters of areas with different values. In addition, G_i^* statistics is used to detect local pockets of dependence that may not show up by using global spatial autocorrelation methods, suggested by Getis and Ord (1992).

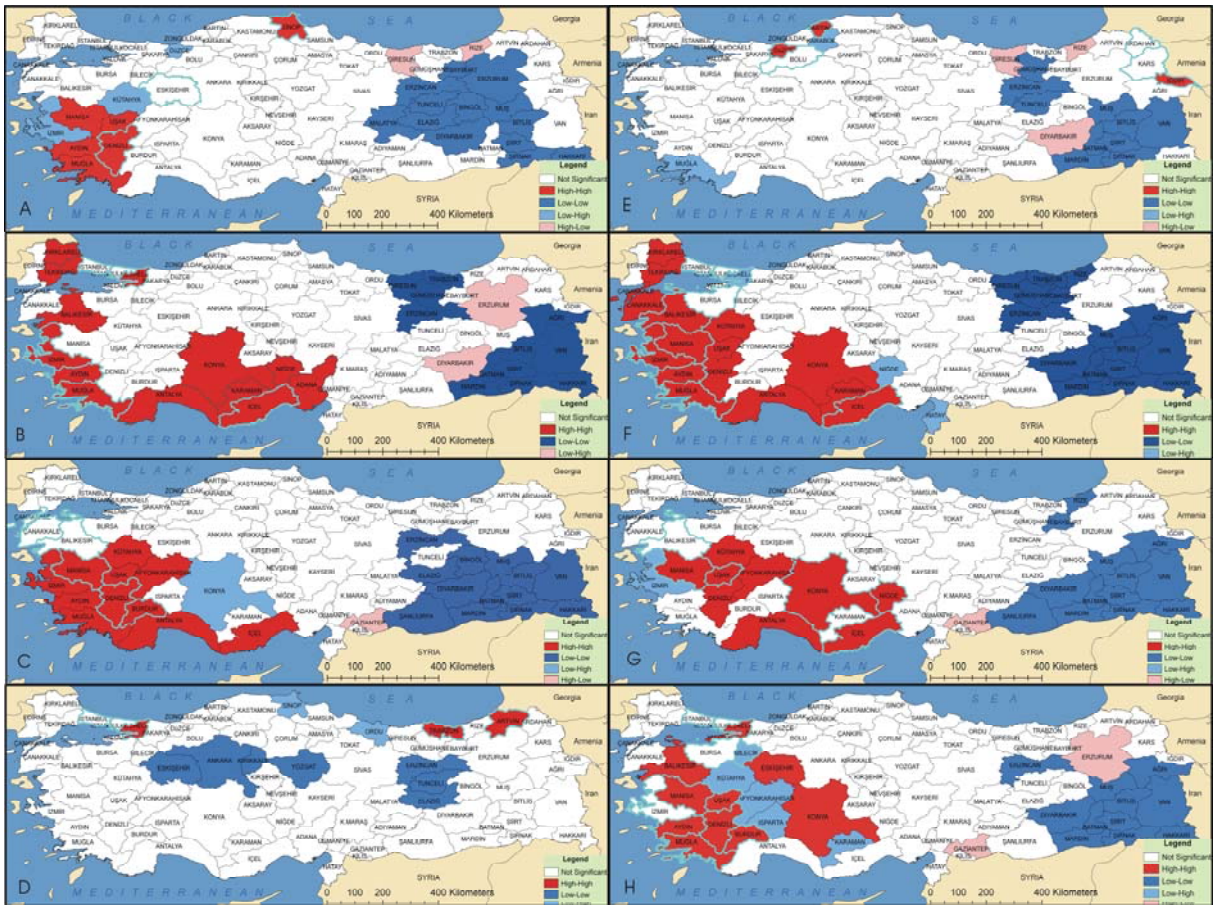

Figure 2. Cluster maps of crime rates A:Homicide rates, 1997-2001 period, D:Crimes related with firearms and knifes, E: Homicide rates 2002-2006 period, H: Swindling, C: Assault and battery 1997-2001 period, G: Assault and battery 2002-2006 period, B: Theft 1997-2001 period, F: Theft 2002-2006 period

3. RESULTS

The first step to identify possible patterns of crime rates is to map the phenomena and conduct an exploratory spatial data analysis. The distribution of smoothed rates and excess risk rates (with a standard deviation classification) of crimes in the Turkish provinces were presented in Figure 1.

When the ratio of province where the crime was committed by convicts in total convicts is examined, it is seen that the ratios of convicts committed crime in the West and Mediterranean provinces are higher than the ratios of convicts committed crime in the east and north regions of Turkey. However, crime is a very complex phenomenon and needs to be investigated carefully to catch important provincial disparities. When the crime rates examined for different periods province by province, the distribution of crime types is different from each other's. Crimes related with firearms and knifes is accumulated in the coast area of the country. Samsun and Rize provinces are determined the most risky provinces in terms of excess risk. In both periods, high homicide rates are gathered in the Aegean and Black Sea regions. A decrease is seen in homicide rates after 2001 year. Kars is the most risky

province in terms of excess risk in the period of 2002-2006. Manisa, Uşak, Kastamonu, Ardahan, Iğdır, Sinop and Samsun provinces have high homicide rates too. Swindling rates are lower in the Black Sea region and in the east of Turkey. Except Uşak, all of the provinces determined as risky in terms of excess risk rates are metropolitan provinces. Theft rates are lower in the Black Sea region and in the east of Turkey too. Except Manisa and Yalova in both period, and Aydın in 2002-2006 period, all of the provinces, which are determined as risky in terms of excess risk, are metropolitan provinces too. In terms of assault and battery rates, Karaman is the most risky province. Balıkesir, Eskişehir, Uşak, Aksaray and Ardahan provinces have high assault rates too.

As show in the Table 1, except the crimes related with firearms and knifes, it is immediately seen that positive spatial autocorrelation exists with the 0.05 level of significant for all kind of crimes, both using Moran's I and Geary's C statistics. However, there are interesting differences for crimes across time. Concluding this section relative to the ESDA, it can be said that crime activities in Turkish provinces are affected by spatial autocorrelation that changes over ten-year period. The spatial autocorrelation is more relevant in 2002-2006 period and decreases in the 1997-2001 period. The spatial autocorrelation is substantially the same, considering the geographical proximity or contiguity, and shows similar patterns using the different weights matrices. However, any clustering detected with Getis-Ord G indices. Since clustering of high crime rates clustering is not detected, local spatial autocorrelation test statistics were used to detect local pockets of dependence that may not show up when using global spatial autocorrelation methods. The provincial level of spatial auto correlation analysis, allowed us to detect for intra-regional disparities in terms of crime rates.

One local approach is Getis Ord Gi* and the other is LISA that were used for analyzing spatial association to identify where the similar spatial patterns in the country are. Getis Ord Gi* identified those clusters of points with values higher in magnitude than you might expect to find by random chance. The clusters detected by Getis-Ord Gi* are shown with turquoise color (Figure 2). According to Getis-Ord Gi* values , Eskişehir, Denizli and Sinop for 1997-2001 period, Düzce, Bolu, Bartın, Iğdır, Kars and Ardahan for 2002-2006 period are determined as clusters in terms of homicide rates with the significance level of 0.05. Other local approach is local Moran LISA statistic that assessed using a normal distribution approximation. Because of similarities between the geographical distance and the proximities weights tests for spatial autocorrelation, here only the LISA results for the queen contiguity matrix are shown (Figure 2). Four situations are identified trough LISA. First, a cluster of provinces with high-high rates with powerful crime rates, second a cluster of provinces with high-low rates, third a cluster of provinces with low-high rates and fourth a cluster of provinces with low-low rates. According to LISA values, Uşak, Aydın, Denizli, Muğla, Sinop and Manisa for 1997-2001 period, Düzce, Bartın and Iğdır for 2002-2006 period are determined as clusters with significance level of 0.05. Southwest region is detected as problematic for the 1997-2001 period in terms of high homicide rates. In terms of theft rates, east of Turkey is problematic. While in the 1997-2001 period only edge of the East Anatolian is determined as problematic, in the 2002-2006 period problematic provinces with high theft rates enlarged to the internal Aegean region. Except the Bursa and İstanbul provinces both method detected the same provinces as clusters too. Southeast region and East Black sea regions detected as clusters with low theft rates. Southwest region is detected as problematic in terms of high assault and battery rates. Except the Balıkesir and Çanakkale provinces both

method detected the same provinces as clusters too. There is a movement towards the east in the 2002-2006 period. There is not a clear clustering in terms of crimes related firearms and knifes. Kocaeli, Trabzon and Artvin provinces are determined as clusters significantly with both methods. Except the Bilecik and İstanbul provinces both method detected the same provinces with high swindling rates. Most of the provinces determined as risky with high swindling rates are metropolitan provinces. Gi* statistics and LISA results were indicated nearly the same provinces and regions as clusters. Meanwhile, there are some differences too.

4. CONCLUSION

Turkey is a developing country. Political and economic changes and changes in the social structure occur due to migration especially in the large and touristic cities of the country. These situations lead problems in some crime rates. Therefore, an ecological study was conducted. This paper represented the first attempt to do this for measures of crimes in Turkey. Therefore, this study is an important methodological exercise, given the growing interest in and studies of violence in Turkey.
The results demonstrated that Bayesian and risk maps are useful tools for identifying regional patterns in crime rates. Bayesian maps had smoother appearance, demonstrating more clearly the spatial pattern of criminal statistics. According to the results, criminal activities were non-random in time and space. Except rates of crimes related with firearms and knifes, all crime types showed clustering with the use of different weight matrices. The use of different weights matrices to detect crime activities confirmed that the geographical proximity is relevant, and that relational proximity should be appropriately investigated. Crime is highly clustered in east and southeast of Turkey. Both global and local spatial autocorrelation indices confirmed this characteristic. Especially swindling and theft rates had a clear visual clustering.

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BIOGRAPHICAL NOTES

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