DISTRIBUTION OF CRIME ACROSS UKRAINE: PANEL AND SPATIAL ANALYSIS

by

Iavorskyi Pavlo

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Thesis Supervisor: _____ Professor Shepotylo Oleksandr

Approved by _____

Head of the KSE Defense Committee, Professor Wolfram Schrettl

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Date _____

Kyiv School of Economics

Abstract

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This study investigates the nature of pattern of crime distribution in Ukraine as well as whether a spatial dependence is present in crime distribution. As an instrument to answer these questions, panel analysis and spatial lag model are estimated for total crime and four specific types of crime. The results show that crime distribution is sensitive to socio-demographic characteristics such as morality, urbanization and education. Moreover, police efficiency and poverty level are important crime incentives. Spatial analysis shows the significance of spatial spillovers.

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Chapter 1

INTRODUCTION

Crime is an inseparable part of a functioning of any society. In one way or another every member of society feels the impact of criminal activity and there are almost no utopians who believe in the possibility of eradicating this social ill. The phenomenon of crime in the form of corruption, murder, robbery etc takes place: from the wild African kingdoms to the leaders of the world economy. And, unfortunately but naturally, Ukraine is not an exception.

Ukraine as well as other post-Soviet countries experienced a devastating period of 1990s. The collapse of the Soviet Union launched processes which completely changed the lifestyle of Ukrainians. On the ruins of the planned economy under the absence of control by the state (and to a greater extent with the support of it) the country was flooded with crime.

The economic recovering from the collapse of 1990s began only in 2001-2002 years but social and demographic costs are irreparable. In the everyday life of ordinary Ukrainian citizens the concepts of the criminal world ("strelka", "ponyatiya", "bratva" etc) joined and strengthened. This list is almost endless. Criminal wars were the main topics of news and dozens of specialized TV programs. Literature and film industry as litmus tests showed tendencies in society: strong skinhead guys dressed in leather jackets and hung with gold chains became the embodiment of the new "Ukrainian dream". Their Law "The strongest takes all" has become the basic principle of the daily and political life in our country while formal legislation was seen as something unworthy of paper on which was written.

The areas with a reputation for banditry estates where no one can feel safe emerged on the territory of Ukrainian cities. Troyeshchyna and Otradnyi in Kyiv, Solnechnyi and Kommunar in Dnipropetrovs'k, Syhiv in Lviv, Poskot in Odessa, Textilschik in Donetsk and HTZ in Kharkiv became symbols of the immorality, economic devastation and hopelessness. Moreover, such perceptions shifted to the national level. As a result, residents of Zaporizhia or Donetsk regions automatically get branded as criminals. The Ministry of Home Affairs confirmed these stereotypes: the general crime rate in the industrialized eastern and southern regions is higher than in the west and center of the country. Such a reputation is likely to bring significant economic losses in these regions. Therefore, it is very important to find what defines this pattern. What differences between the East and the West are responsible for such a distribution of criminal activity? What the factors of social and economic development significantly affect crime rate in Ukraine. Is there a so-called neighborhood or spatial effect, and how strong is it? The purpose of this thesis is to answer these questions.

The thesis is structured as follows: Chapter 2 presents the literature review; the Chapter 3 and Chapter 4 describe methodology and data used in this study respectively. Then Chapter 5 provides an empirical analysis and, finally, Chapter 6 summarizes all results of this study.

Chapter 2

LITERATURE REVIEW

In this chapter the important and pertinent literature on the crime determinants and spatial distribution of crime is analyzed and summarized. This section is divided into three parts which present two aforementioned topics. The first subsection describes most important studies which provide theoretical foundation of economic crime model. The second subsection provides review of empirical studies of crime. The last subsection describes literature that studies of spatial distribution of crime.

The first attempt to analyze crime from an economic perspective is a merit of Fleisher (1966). His study focuses on the role of income in making a decision to commit illegal act by individuals. Fleisher states that lower income increase the probability of committing crime and justifies his opinion by the fact that lower income decrease the relative cost of crime and cost of being caught. Moreover, he finds that income level of victim is also a strong crime incentive. This means that inequality in wealth distribution is an important factor that has positive effect on crime activity.

Fleisher's paper is empirical and does not provide formal model. Becker (1968) is the pioneer of a theoretical justification for crime behavior. His crime economic model (CEM) is based on the principle of individual's rational behavior. In other words, a person acts illegally if marginal benefits of crime are higher than its marginal costs. According to this approach, Becker constructs a function that relates the number of offense by each individual to the probability of getting caught, severity of punishment, reward of illegal act and income from

legal activities. Logically, offense function negatively depends on the first three factors and positively on the latter. To generalize results for the entire population Becker assumes average values of all variable and find total offense function as a sum of individual functions. He concludes that the optimality of public crime policy is determined by expenditures on police and courts, the size of punishment and the form of punishment.

Becker's economic crime model was expanded by Ehrlich (1973) who investigates how income level and income inequality affect crime rate for different types of crime. His main findings are that higher income inequality is associated with higher crime rates, and, in the same time, higher income (measured as median family income) is associated with higher crime rate, which is a contradiction to Fleisher's results. In addition, Ehrlich concludes that unemployment rate has a less significant effect on crime rate than income and its distribution.

The next steps in the development of economic crime model are a merit of Block and Heineke (1975). They shows that results obtained by Becker (1968) and Ehrlich (1973) are not general and represent special cases. They criticize previous papers for that crime is defined as a function of wealth only. Block and Heineke take into account time spent in two activity types (legal and illegal) whereas Becker and Ehrlich mostly focus on number of crimes rather than time.

Aforementioned papers represent the theoretical background of economic model of crime. They show that crime decision is a result of maximization problem when an individual compare benefits and costs of crime.

Since the late eighties researchers' attention shifted from theoretical to empirical crime models. These models depart from cost-benefit analysis and focus on social and economic determinants of crime. The majority of studies pay attention to relation of crime and inequality, unemployment, education and age structure of the population controlling for other demographic and cultural characteristics. Moreover the object of study may be different types of criminal activity such as violent crime, property crime etc. This subsection provides a summary of the most influential papers.

Already in early studies on the economics of crime unemployment is seen as one of the most important factors. Fleisher (1963) and Ehrlich (1973) believe that the majority of criminals are not employed and unemployment positively affect crime rate. However, several researches show that the situation is opposite. Particularly, Freeman (1994) finds that although trends of criminal activity and unemployment are similar, the crime-unemployment relationship is insignificant. Imrohoroglu et al (2001) find that approximately 79% of prisoners were employed prior to crime committing which contradicts the classical ideas.

On the other hand, Lu Han et al (2010) and Witt et al (1998) detect a significant effect of unemployment in the studies concentrated on England and Wales at the level of police areas.

To sum up, the relationship between crime and unemployment is ambiguous and depends on types of study (time-series, cross-section or panel) as well as a specification of model. In particular, the definition of unemployment (the total unemployment or segmented by age groups) may result in different conclusions. In general, age structure of population is closely related to crime.

According to Freeman (1994), age distribution within population is connected to criminal activities through inequality in earning. It is a well-known fact that income of youth is lower than income of other age groups and, therefore, young people are more prone to illegal activities. Such a pattern is called the age-crime profile and was found by Quetele (1831) who showed that crime rate increases rapidly during teen age with a peak in the mid twenties and then falls. Siu Fai Leung (1992) analyzes the age-crime profile from economic point of view and concludes that crime intensity cannot be found just from it. This conclusion can be considered as an argument in support of Freeman's idea about income nature of this relationship.

The same situation is in the relationship between crime and education. A significant number of studies shows that criminals tend to have lower education level and come from more disadvantaged groups of population than non-criminals. Education affects crime intensity in different ways. Firstly, it increases returns to legal activities through improvement in individual's skills and, logically, increases opportunity costs of illegal act. Moreover, education affects individuals' preferences through psychological aspect. This effect is called "civilization effect" and means that a person who received higher education is less likely to commit crime because of psychological restrictions.

All abovementioned factors such as age distribution, unemployment and education in one way or another are connected with criminal's income level. But, according to Fleisher (1966), income level of another, victim's side of crime also matters. Therefore, income distribution or inequality in distribution of income is an object of interest in enormous number of studies. However, the results vary substantially with types of studies and types of crime.

Fanjzylber et al (1998, 2002, 2002) find positive effect of inequality on robbery and homicide rates in panel analysis at country level. Kelly (2000) receives positive effect on violent crime, assault, robbery and burglary; negative effect on rape and no significant effect on property crime, murder, larceny and car crime. Soares (2004) detects that inequality positively affect thefts and negatively affect burglary.

After presenting the literature on theoretical foundations of economic crime model and its empirical application, this chapter switches to the second subtopic and concentrates on spatial models of crime distribution.

Spatial econometrics is special subfield of econometrics that focuses on spatial or so-called "neighborhood" effects in regression analysis. This methodology is widely and successfully used in sociology, regional sciences and different subfields of economics.

Although the roots of the spatial econometrics go into seventies (Ord, 1975; Paelinck and Klaassen, 1979; Cliff and Ord, 1981), Anselin has a considerable influence on its development. In the long list of his studies he classifies the main types of spatial effects (Anselin, 1988), specifies regression models (Anselin, 1988; Anselin et al, 1996) and justifies its testing and estimation methodology (Anselin, 1980; 1986). Today, spatial econometric analysis is booming and is used in a variety of research areas and, particularly, in studying economics of crime.

The main idea of spatial crime studies is a diffusion of crime between spatial units. It means that crime rates of region are likely to be higher if a neighboring experiences high illegal activity. Moreover, the concept of "region" varies from suburban areas to international level.

The majority of empirical studies of spatial crime are cross-sectional studies. Cameron (1999) uses explanatory spatial data analysis (ESDA) to show a spatial pattern of different crimes in counties of Appalachia. He applies global Moran's I statistics (Moran, 1948) to determine a presence of spatial autocorrelation, and LISA analysis (Local indicators of Spatial Autocorrelation) to find so-called "hot-spot" counties. Original application of local Moran's I statistics for geographical analysis is attributed to Anselin (1995). He uses LISA to find clusters in distribution of some characteristics. This methodology is commonly used in spatial crime analysis.

Almeida et al (2003) applies it for crime activities in Minas Gerais, Brazil. Cracolici et al (2008) combines LISA with classical spatial analysis in their study of crime distribution in Italy. The most important finding of Italian researchers is a strong and highly significant effect of punishment severity on intensity of all crime types (murder, fraud, theft and squeeze).

Andresen (2006) investigates crime activity in Vancouver, Canada. He finds strong spatial correlation of automobile thefts, violent and property crimes. Breetzke (2008) confirms these results in the case of South Africa study. Moreover, he concludes that unemployment and migration is highly related to violent and economic crime but does not find such an effect on sexual crime.

Soares (2009) finds that crime has positive relationship with income and income inequality, migration and urbanization, share of young people (15-17 years old), religious and morality (measures as share of adolescent mothers) of population. On the other hand, education (school attendance) and police efficiency tend to decrease crime rates.

The further step in development of spatial econometrics is a paper of Elhorst (2003). He specifies and develops methodology of estimation spatial error and spatial lagged panel data models. This methodology includes procedures for fixed and random effects.

Chapter 3

METHODOLOGY

This section consists of two parts. The first part describes the methodology used in an analysis of crime determinants for country and regional level. The second part provides the description of spatial model of crime distribution.

According to empirical studies discussed in the chapter 2, the crime model can be specifies in the form of equation (1) and estimated by Ordinary Least Squares with Newey-West corrected standards error in the presence of heteroscedasticity or serial correlation:

$$\begin{gathered} \ln(Y) = \beta X + \varepsilon, \\ \varepsilon \sim N(0, \sigma^2 I) \end{gathered} \tag{1}$$

where Y is a $[N \times 1]$ vector of crime rate, X is a $[N \times N]$ matrix of explanatory variables, β is a $[N \times 1]$ vector of regression coefficients and ε is a $[N \times 1]$ vector of error terms.

In empirical studies different independent variables are used with focus on socio-economic and socio-demographic characteristics. Based on these studies the set of explanatory variables of aforementioned model is specified as follows:

1. Socio-economic Characteristics:
    - Economic development of region: the level of economic well-being of region is considered as one of the most influential factors of crime activity. Empirical studies show that economic development negatively affects participation in illegal acts;

- Income level of region: generally, these characteristics are separated into two types which are inequality in income distribution and total level of income of population. From theoretic point of view, both characteristics are positively related with crime rates, which is confirmed by empirics;

- Unemployment: according to Becker's CEM participation in legal activities can be treated as an opportunity cost to crime. Therefore, crime rates and unemployment are expected to move in the same direction.

2. Socio-demographic Characteristics:

   - Share of young people: generally, young people are more likely to commit crime;

   - Urbanization: a concentration of population, especially in urban areas, increases an illegal activity.

   - Education: In the literature, education level is considered as a factor that leads to decrease in crime rates. Education directly raises opportunity costs of crime committing and affect crime participation in several indirect ways.

3. Specific Characteristics:

   - Police functioning: in Becker's CEM the probability of being caught and severity of punishment are important determinant of crime committing decision. Empirics uses police expenditures, number of police officers per 100,000 people and detection rate as a measure of police functioning;

   - Morality: cultural and moral level of population has significant influence on crime activity. In empirical studies single mother rate, share of children born to single mothers and share of children born

to mothers aged up to 18 are common proxies of culture and morality;

- Geographical dummies: the purpose of this study is to investigate differences between Western and Southern-Eastern regions. It would be implemented by implementation of regional dummies. Western group includes Zakarpattya, Chernivtsi, Lviv, Volyn, Ivano-Frankivsk, Ternopil and Rivne while Eastern-Southern group comprises Lugansk, Kharkiv, Donetsk, Zaporizhzhya, Dnipropetrovsk, AC Crimea, Sevestopol, Kherson, Mykolaiv, Odessa, Chernigov, Sumy and Poltava.

The general specification of spatial autoregressive models (SAR) can be represented as system of equations (2) (Anselin 1988).

$$\begin{gathered} \ln(Y) = \rho W \ln(Y) + \beta X + \varepsilon, \\ \varepsilon = \lambda W \varepsilon + u,\ u \sim N(0, \sigma^2 I), \end{gathered} \tag{2}$$

where Y is a $[N \times 1]$ vector of crime level, X is a $[N \times N]$ matrix of explanatory variables, W is a $[N \times N]$ row-standardized weights matrix, β is a $[N \times 1]$ vector of regression coefficients, λ and ρ are spatial coefficients and ε and u are $[N \times 1]$ vectors of error terms error terms.

However, the majority of crime studies focuses on two special cases of SAR, namely, spatial lag model (SLM) and spatial error model (SER) whose general forms represented by equation (3) and (4), respectively.

$$\begin{gathered} \ln(Y) = \rho W \ln(Y) + \beta X + \varepsilon, \\ \varepsilon \sim N(0, \sigma^2 I) \end{gathered} \tag{3}$$

$$\begin{gathered} \ln(Y) = \beta X + \varepsilon, \\ \varepsilon = \lambda W \varepsilon + u, u \sim N(0, \sigma^2 I) \end{gathered} \tag{4}$$

The estimators received by Ordinary Least Squares are biased and inconsistent. Therefore, Generalized Method of Moments (GMM) and Maximum Likelihood (ML) are preferable techniques. This paper follows an estimation framework developed by Anselin (1988 and 1995) which is a general approach to estimate spatial models:

1. Spatial lag model:

The model (3) can be gradually rewritten as:

$$(\mathrm{I}- \rho W)\ln(Y) = \beta X + \varepsilon \tag{5}$$

and

$$\ln(Y) = (\mathrm{I} - \rho W)^{-1}\beta X + (\mathrm{I} - \rho W)^{-1} \tag{6}$$

In the case of LM estimation, the log-likelihood function is

$$ln\, L(\beta, \lambda, \sigma) = -\frac{R}{2} ln(\pi) - -\frac{R}{2} ln(\sigma^2) + ln\big||I - \rho W|\big| - \frac{1}{2\sigma^2}\big((I - \rho W)\, ln(Y) - X\beta\big)'\big((I - \rho W)\, ln(Y) - X\beta\big) \tag{7}$$

2. Spatial error model:

The model (4) can be gradually rewritten as:

$$\begin{aligned} ln\,(Y) &= \beta X + \varepsilon, \\ (I - \lambda W)\varepsilon &= u \end{aligned} \tag{8}$$

The log-likelihood function of SEM can be presented as follows:

$$ln\, L(\beta, \lambda, \sigma) = -\frac{R}{2} ln(\pi) - -\frac{R}{2} ln(\sigma^2) + ln\big||(I - \lambda W)|\big| - \frac{1}{2\sigma^2}(ln(Y) - X\beta)'(I - \lambda W)'(I - \lambda W)(ln(Y) - X\beta) \tag{9}$$

3. Local Indicators of Spatial Autocorrelation:

The local Moran's I statistics is calculated according to the following equation:

$$I_i = Z_i \sum_j W_{ij} Z_i \tag{10}$$

The main idea of LISA analysis is to identify spatial clusters. According to Anselin (1995), there are four types of clusters that correspond to four quadrants in figure 1(a slope of line through origin is a value of global Moran's I):

a. Pure "hot spots" or High-High (HH) – high home indicator corresponds to high neighbors' indicators.
b. Pure "cool spots" or Low-Low (LL) - low home indicator corresponds to low neighbors' indicators.
c. Low-High (LH) - low home indicator corresponds to high neighbors' indicators.
d. High-low (HL) - high home indicator corresponds to low neighbors' indicators.

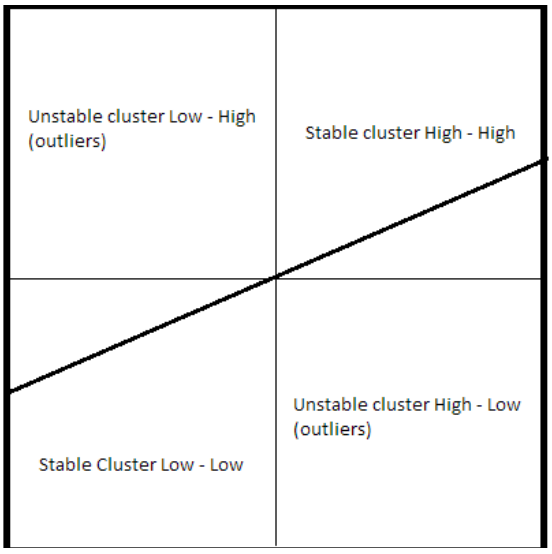

Figure 1. Types of clusters in LISA

One of the based principles of spatial econometrics is a definition of spatial relationship. In the other word, the key question is a construction of weights matrix. There are several groups of commonly applied methods: contiguity, inverse distance, k nearest neighbors and distance band methods.

In this thesis last three approaches are used:

1. Inverse distance method (IDM). In this case row-standardized matrix is created by following rule.

$$\begin{cases} w_{ij} = \frac{1}{d_{ij}} \\ w_{ij} = 0 \; if \;\; i = j \end{cases} \tag{11}$$

2. K nearest neighbors method (KNM). This method takes into account only k nearest entities. It could be used in LISA but is not appropriate for SAR estimation because these models require symmetric weights matrix. In literature it is suggested to use no more than 100 neighbors.
3. Distance band method (DBM). This approach takes into account entities that lie in specified circle. In this thesis minimum distance band is used.

Estimations of spatial models are performed in OpenGeoDa 9.9 software.

Chapter 4

DATA DESCRIPTION

The data comes from the enterprise statistics from the State Statistics Committee of Ukraine. The first dataset is aggregated at oblast level and covers 24 Ukrainian regions, AR Crimea, Kyiv and Sevastopol in the period between 2001 and 2008 years. It includes economic and geographic characteristics of region. The total number of observations is 216. Some of these characteristics are used to construct necessary explanatory variables. The final dataset contains following variables:

- Crime rates: total crime, rape, murder, robbery and theft rates in region. It's measured as a number of crimes per 100.000 people;
- Urbanization: urbanization level. It's measured as a ration of urban population to total population, %;
- Morality: constructed as a share of children born to single mothers, %. In fact it's an amorality, therefore, expected effect is positive;
- Gross regional product and growth: indicators of economic development of region (bln UAH and %).
- Detection rate: measure of police efficiency. It's constructed as a ratio of the number of detected crimes to the number of registered crimes, %.
- Young: the share of people aged 14-24 years.
- Inequality level: describe a distribution of wealth between different groups of population. It's constructed as a ratio of income of 10% richest people to income of 10% poorest people, %.

- Poverty rate: the share of people those incomes are lower than cost of living, %; subsidy rate.
- Unemployment: the share of unemployed people, %.
- Education**:** describe educational level of region. It's constructed as a ration of the number of students at universities and ptus to the number of people aged 14-24 years; the rate of employees with high education.

The descriptive statistics of these variables is presented in Table 1.

Table 1. Descriptive statistics of the first dataset, 2001-2008

Variable	Mean	Std. D.	Min	Max
Crime rate	894.8012	307.1832	387	1725
Murder rate	6.865187	2.955704	1.62837	15.21392
Rape rate	1.989519	0.602845	0.633255	3.952569
Robbery rate	68.37552	34.01158	20.87138	185.0618
Drugs Rate	115.3119	50.064	38.37743	248.4704
Morality	19.78916	7.287707	5.8	31.7
GRP	12777.25	12886.31	2213	104687
Urbanization	0.599041	0.134543	0.407501	0.942125
Detection rate	0.550207	0.076801	0.384779	0.787692
Young	0.151713	0.008982	0.130893	0.167723
Growth	0.254937	0.100772	0.052854	0.579465
Inequality	3.642169	0.513248	2.4	5.2
Poverty	60.02012	23.92562	10.62	98.1
Unemployment	8.729518	2.666703	3.3	17.1
Education	0.313109	0.064603	0.168095	0.457736

The main purpose of this thesis is to explain differences between Western and Eastern-Southern regions. Table 2 compares main characteristics of these subgroups. The last three columns of table present results of testing of statistical difference of means. Tests show that economic growth, education and rape rate are statistically equal across Ukrainian sub regions, while total crime rate, drugs

rate, theft rate, morality, urbanization and income inequality are statistically different. As a general result it could be concluded that total crime, murder, robbery and drugs rate, GRP, urbanization and inequality are higher in Eastern regions, On other hand morality, detection rate share of young people, poverty and unemployment is lower.

Table 2. Descriptive statistics for regional subgroups, 2001-2008

Variable	West	Cent	East	CW	CE
Crime rate	618.48	776.71	1133.79		
Murder rate	4.87	6.19	9.02	**	
Rape rate	2.27	2.44	2.23	*	*
Robbery rate	51.57	64.42	92.89	*	
Drugs Rate	73.72	88.55	150.65		
Morality	11.45	19.32	25.03		
GRP	8817	19208	19829		*
Urbanization	0.48	0.59	0.73		
Detection rate	0.56	0.56	0.53	*	
Young	0.16	0.15	0.15		*
Growth	0.25	0.27	0.27	*	*
Inequality	3.38	3.85	3.60		
Poverty	63.42	56.87	57.90		*
Unemployment	9.70	8.89	7.95	*	
Education	0.30	0.38	0.35	**	*

**- 10%, ** - 5% (stars mean that means are statistically equal)*

The second dateset is used in cross-sectional spatial analysis and covers period between 2003 and 2006 at rayon level. The data about different type of crime are not available for this level and, therefore, distribution of total crime is analyzed. Dataset contains the following variables those descriptive statistics is presented in table 3:

- Crime rate: total crime It's measured as a number of crimes per 100.000 people;
- Urbanization: urbanization level. It's measured as a ratio of urban population to total population, %;
- Morality: number of deliveries by mothers aged up to 18, It's measured as a number of deliveries per 100.000 people;
- Gross regional product: indicator of economic development of region (bln UAH).
- Detection rate: measure of police efficiency. It's constructed as a ratio of the number of detected crimes to the number of registered crimes, %.
- Young: the share of people aged 14-24 years.
- Inequality level: describe a distribution of wealth between different groups of population. It's constructed as a ratio of income of 10% richest people to income of 10% poorest people, %.
- Unemployment: the share of unemployed people, %.
- Education: the rate of employees with high education. It's measured as a number of employees with high education per 100.000 people;
- Longitude and Latitude: geographical coordinates of region capital.

Table 3. Descriptive statistics of the second dataset, 2003-2006

Variable	Mean	Std. D.	Min	Max	0.25	Median	0.75
Inequality	3.684	0.517	2.4	5.3	3.3	3.6	3.9
Unemployment	5.361	3.172	0	18	3	5	7
Morality	26.317	19.833	0	149.813	13.29	21.84	34.26
Urbanization	44.61	31.29	0	100	23.2	34.9	56.3
GRP	14.417	13.791	1.724	95.267	6.275	9.014	18.1
Education	3913	1981	25.48	15367	2945.9	3427.	4210.1
Detection rate	0.523	0.067	0.263	0.668	0.467	0.518	0.571
Young	0.154	0.009	0.138	0.183	0.145	0.156	0.161

Chapter 5

EMPIRICAL RESULTS

This section presents empirical estimation of model and analysis of results. At the first stage a panel analysis of model (2) is performed. The second stage provides results of spatial models estimations.

For panel analysis three specifications are estimated. Results of estimations for total crime are presented in table 4. The initial model includes only geographical dummies and confirms a significant difference between Ukrainian regions. Then two groups of explanatory variables namely, socio-demographic and economic have been added. Results of final model are consistent with initial and the second model: the crime rate is 0.07 per cent lower in Western regions and 0.11 per cent higher in Eastern regions. The significant determinants of total crime rate are moral well-being of population, level of urbanization, poverty rate and police efficiency. The effects of the first three are positive: 0.02, 0.757 and 0.005 per cent respectively. The largest impact has police functioning – 1 per cent increase in a detection rate leads to 1.068 per cent decrease in a rate of criminal activity.

Table 5 contains estimation results of final model for specific types of crime (for intermediate models, see tables A1-A4, appendix A). First of all, there is no such a geographical dependence as in the case of a general crime. Geography is insignificant for murders and robberies for both sub regions and.

However, there is "west" effect for rapes and "east effect" for drugs: rape rate is 0.204 per cent lower in Western regions while drugs rate is 0.219 per cent higher in Eastern regions.

Table 4. Total crime estimation results.

	1	2	3
West	-0.228***	-0.082*	-0.068**
	(-4.152)	(-1.715)	(-2.011)
East	0.379***	0.150***	0.113***
	(8.02)	-3.501	(3.476)
Morality		0.013***	0.020***
		(3.797)	(7.331)
Urbanization		0.782***	0.755***
		(4.461)	(5.895)
Police		-1.077***	-1.068***
		(-4.325)	(-5.757)
Young		-1.002	0.239
		(-0.590)	(0.197)
Education		-0.307***	-0.059
		(-2.896)	(-0.692)
GRP			-0.012
			(-0.765)
Growth			0.134
			(1.406)
Inequality			-0.022
			(-1.144)
Poverty			0.005***
			(8.21)
Unemployment			0.006
			(1.253)
Constant	6.631***	6.810***	6.260***
	(173.172)	(23.734)	(19.8)
N	216	207	207
R-sq	0.588	0.787	0.888
R-sq, adj.	0.584	0.779	0.881

*Note: t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01*

Poverty, urbanization, education and morality are important determinants of almost all types of crime with some exceptions: urbanization and poverty do not affect drugs rate, education – robbery rate, morality – rape rate. On the

other hand, age structure of population has strong effect on robberies and rapes - 7 and 15.3 per cent respectively.

Table 5. Estimation results for different types of crime

	Murder	Rape	Robbery	Drugs
West	-0.046	-0.204**	0.108	0.142
	(-0.708)	(-2.033)	(1.424)	(1.623)
East	0.037	-0.142	0.007	0.219***
	(0.724)	(-1.492)	(0.122)	(2.696)
Morality	0.029***	0.004	0.028***	0.035***
	(6.657)	(0.487)	(5.267)	(6.74)
Urbanization	1.722***	1.275***	0.947***	0.361
	(7.667)	(3.758)	(3.336)	(1.243)
Police	0.959	0.935	-1.725*	-0.583
	(1.273)	(1.094)	(-1.741)	(-1.488)
Young	-0.975	15.334***	6.998*	1.621
	(-0.292)	(3.291)	(1.661)	(0.442)
Education	-0.500***	-0.448*	-0.082	-0.830**
	(-3.209)	(-1.842)	(-0.433)	(-2.085)
GRP	-0.046	-0.056	0.006	0.161***
	(-1.504)	(-1.271)	(0.189)	(4.279)
Growth	0.041	0.122	0.237	0.054
	(0.271)	(0.356)	(0.898)	(0.238)
Inequality	0.028	-0.079	0.066	0.039
	(0.639)	(-1.312)	(1.333)	(0.834)
Poverty	0.008***	0.003*	0.004**	0.002
	(5.412)	(1.925)	(2.355)	(1.637)
Unemployment	-0.008	0.004	-0.052***	-0.016
	(-0.674)	(0.241)	(-4.105)	(-1.182)
Constant	-0.084	-2.223*	2.725**	2.333***
	(-0.088)	(-1.744)	(2.203)	(2.877)
N	199	199	199	166
R-sq	0.736	0.261	0.682	0.721
R-sq	0.719	0.213	0.662	0.699

*Note: t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01*

Other interesting results are influences of police efficiency and economic well-being. First of all, police, that is one of the most influential determinants of total crime, has significant effect only on one "specific" crime, namely, robbery (-1.7%). Level of GRP is positively related to drugs crime (0.16%) and insignificant for other types.

At the second stage total crime cross – sectional spatial analysis is performed for period between 2001 and 2008. First of all, LISA (local indicators of spatial autocorrelation) is performed. A figure 2 presents visualization of received results for 2001 in the case of distance band weights matrix. The patterns are following: High-High and Low-High "spots" are concentrated in the East, Low-Low and High-Low "spots" – in the West whereas local Moran's Is are insignificant for central regions. It means that there is a tendency that: Eastern regions with high crime rate are surrounded by regions with high crime rate; Western regions with low crime rate are surrounded by regions with low crime rate. On the other hand, both sub-regions have clusters of spatial instability: low-criminal Eastern regions adjoin to higher-criminal regions and higher-criminal Western regions adjoin to lower-criminal regions. Moreover, the share of Low-High "spots" is higher than the share of High-Low "spots". The results are the same for 2002-2008(figures C2-C8, appendix C). Figure 3 present results of LISA in the case of k neighbors weights matrix. It's obvious that the results reflect the same tendency.

The next step is an estimation of spatial models. Due to absence of data, these models are estimated for period between 2003 and 2008 (Tables B1-B4). First of all, OLS estimators are tested for spatial dependence. GeoDa provides six different tests (Moran's I, LM (lag) and Robust LM (lag), LM (error) and Robust LM (error)).

Table 6 presents these statistics and it can be concluded that there is no spatial dependence in errors. In other words, spatial lag model is preferable to spatial error model.

Table 6. Testing for spatial dependence, DBM, 2003-2004

	Year			
Test	2003	2004	2005	2006
Moran's I (error)	0.958	0.611	1.681	0.817
LM (lag)	23.168	13.720	20.564	5.630
Robust LM (lag)	36.353	34.404	25.886	9.824
LM (error)	0.098	1.237	0.893	0.034
Robust LM (errors)	13.283	21.921	6.215	4.229
LM (SARMA)	36.451	35.642	26.779	9.858

Table 7 summarizes results of SLM estimation for 2003-2006. The R-coefficient indicates significant positive spatial lag dependence that consistent with global Moran's I statistics of LISA analysis. SLM shows the same results for geographical dummies as panel analysis. For example, in 2003 crime rate is 0.214 per cent lower in Western regions and 0.242 per cent higher in Eastern regions. Moral well-being, unemployment and urbanization still significant determinants of criminal activity, however police efficiency loses its effect. Another difference with panel analysis is a significance of economic well-being of region, however a scale of GRP effect still approximately equal to zero.

Table B5 presents results of SLM in the case of inverse distance matrix. The results are different in some aspects. First of all, likelihood ratio test indicates a presence of spatial dependence only for 2005. Estimations results for this year are the same in both cases.

In order to estimate the scale of spatial effect, the following experiments are performed. According to SLM with distance inverse weights matrix,

urbanization, morality and income inequality are significant determinants of crime.

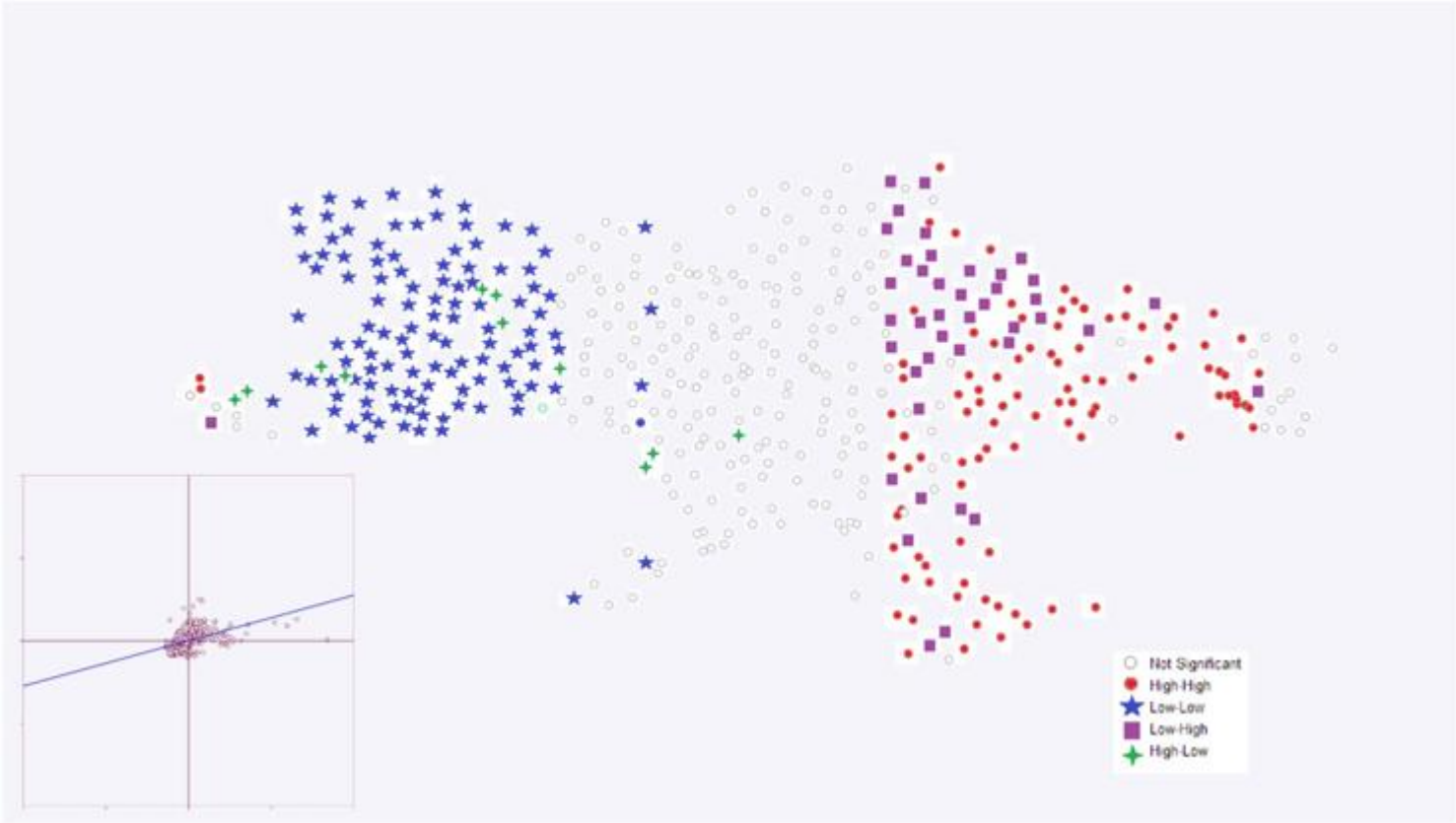

Figure 2. LISA cluster analysis, DBM, 2001

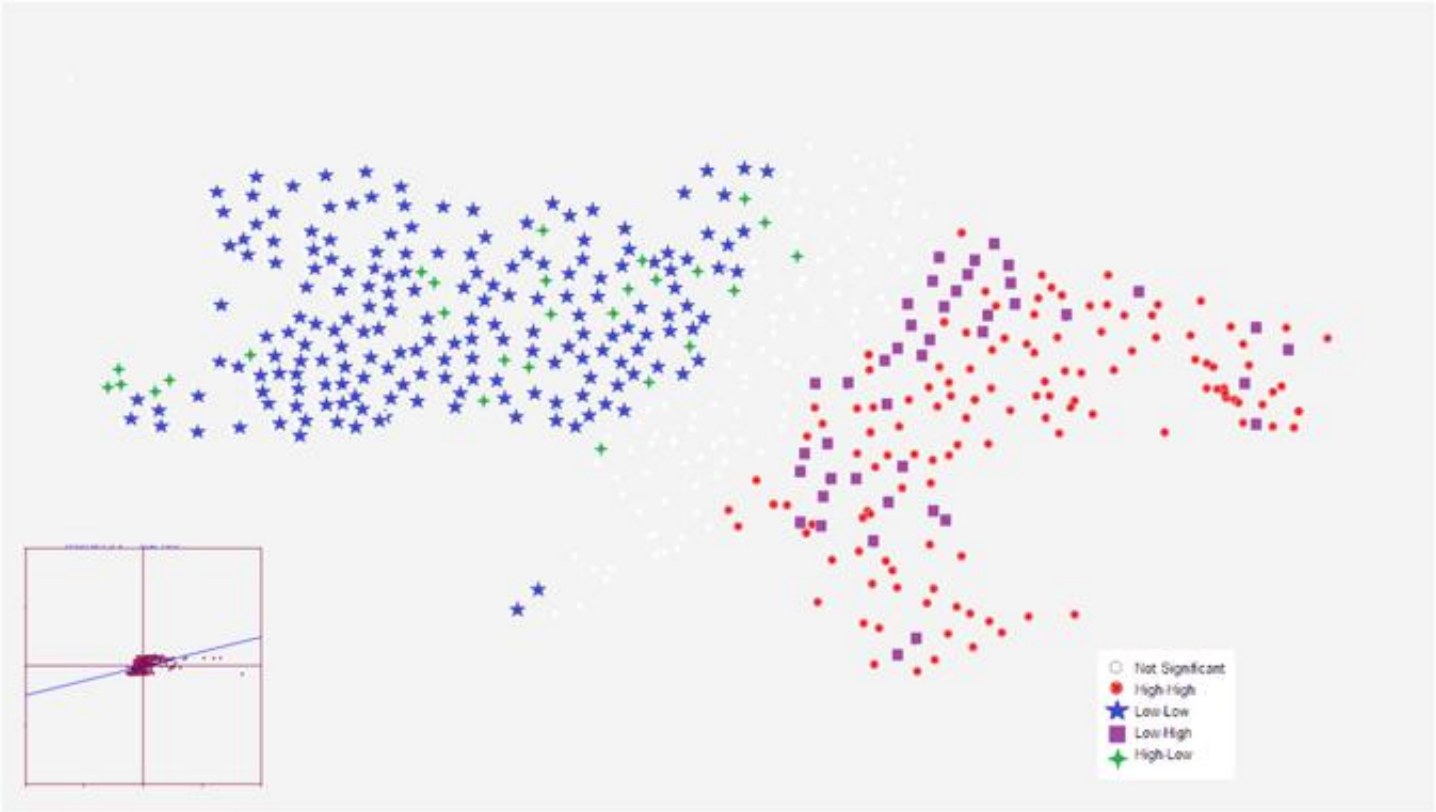

Figure 3. LISA cluster analysis, KNM, 2001.

Table 8 contains a descriptive statistics of these factors for 2005. The following assumptions are applied:

1. Let for some regions with inequality level below the first quadrant, inequality increases up to value of the third quadrant;

Table 7. Spatial Lag Model Estimations, 2003-2006

	2003	2004	2005	2006
R	0.347***	0.285***	0.335***	0.208***
	(4.528)	(3.487)	(4.384)	(2.300)
West	-0.214***	-0.137**	-0.089	-0.151***
	(-3.513)	(-2.127)	(-1.575)	(-2.605)
East	0.242***	0.318***	0.317***	0.252***
	(4.747)	(5.868)	(6.325)	(4.757)
Inequality	0.045	0.006	0.111**	0.047
	(1.086)	(0.171)	(2.31)	(1.299)
Unemployment	-0.002	-0.010**	-0.009*	-0.007
	(-0.453)	(-1.931)	(-1.813)	(-1.194)
Morality	0.037***	0.054***	0.023**	0.030***
	(2.892)	(4.173)	(1.968)	(2.507)
Young	2.940	-2.050	2.568	1.383
	(1.149)	(-0.829)	(0.967)	(0.533)
Urbanization	0.002**	0.001**	0.001**	0.002***
	(2.461)	(2.025)	(2.546)	(3.003)
GRP	0.001**	0.001***	0.001	0.001***
	(2.340)	(2.412)	(0.721)	(2.703)
Education	0.000	0.009	0.014**	0.015**
	(0.129)	(1.098)	(2.001)	(2.003)
Police	0.362	0.370	-0.142	0.111
	(1.627)	(0.870)	(-0.384)	(0.326)
Constant	3.420***	4.531***	3.398***	4.348***
	(4.666)	(5.354)	(4.383)	(5.378)
R-sqr	0.436	0.438	0.440	0.357
Likelihood Ratio	19.28	11.551	12.256	4.239

Note: z statistics in parentheses, p<0.10, ** p<0.05, *** p<0.01*

Table 8. Descriptive statistics, selected variables, 2005

Variable	Mean	Min	Max	0.25	0.75
Inequality	3.788522	2.4	4.7	3.4	3.9
Morality	24.61346	0	142.8571	13.28	34.27
Urbanization	45.92255	0	100	23.2	56.3

2. Let for some regions with urbanization level below the first quadrant, it increases up to value of the third quadrant;
3. Let for some regions where amorality is higher than the third quadrant, it increases to the value of the first quadrant;

Usual and spatial effects of aforementioned experiments are estimated by equations (12) and (13) respectively. The results for selected regions are presented in figures 4, D1 and D2.

$$\Delta Y = \beta_i \Delta X_i \quad (12$$

$$\Delta Y = (I - \rho W)^{-1} \beta_i \Delta X_i \quad (13)$$

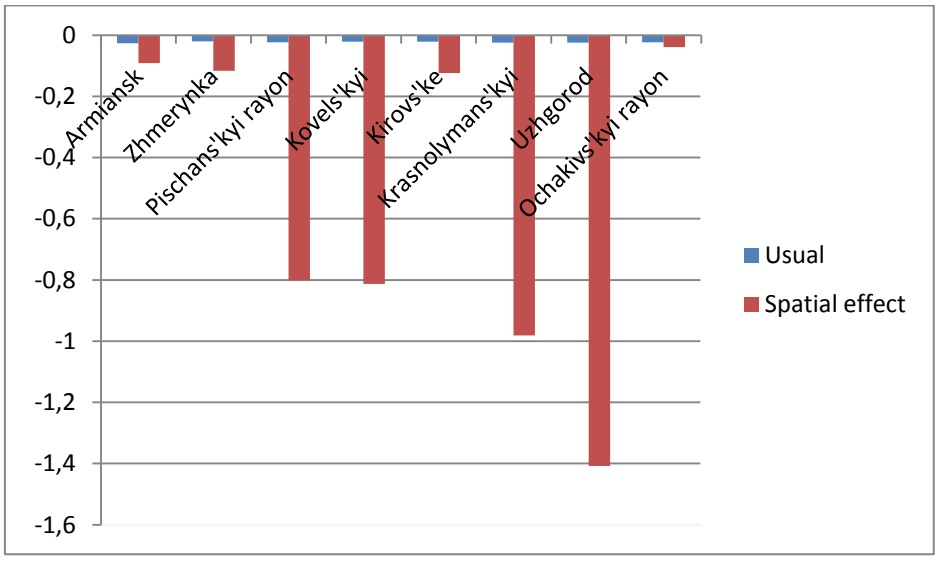

Figure 4. Spatial and usual effect of increase in morality

According to experiments spatial spillover effect is from 1.69 to 32 times higher than usual effect. Moreover there are some outliers with even higher differences between these effects.

Chapter 6

CONCLUSIONS

The results received in analysis of crime distribution allow us to make a conclusion that there is significant difference between Western and Eastern regions. The most important finding is the fact that economic development of Ukraine is not a most influential determinant of crime insensitivity. Gross regional product and its growth as well as inequality in income distribution are insignificant. Poverty is the only economic indicator that has strong influence on crime. It can be explained by the fact that economic development of Ukraine does not lead to significant improvement in life standards of its population. More important are socio-demographic characteristics such as concentration of population in urban areas, morality and police efficiency. According to result, police efficiency is one of the most important instruments to fight crime – improvement in police functioning can lead to significant decrease in illegal activity. Another extremely important factor is level of education that has strong negative effect on crimes. Therefore it could be concluded that Ukrainian crime activity is mostly cultural and psychological phenomenon.

The-+ situation is a bit different with regards to specific crime. Analysis shows that the "perfect" places for the prosperity of sexual violence are poor locations with high concentration of population and high share of young people. On the other hand, crimes connected with drugs are concentrated in more economically developed areas.

The spatial analysis shows strong positive dependence between Ukrainian regions. Therefore, anti-crime policy realized simultaneously in all regions would

be more efficient that limited local programs. Such a policy must include aforementioned improvement in quality of police service and programs of raising cultural and educational level of population, particularly young people who are subject to particular risk.

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APPENDIX A

Table A1. Murder estimations results.

	1	2	3
West	-0.374***	-0.099	-0.046
	(-3.380)	(-1.221)	(-0.708)
East	0.406***	0.083	0.037
	(5.475)	(1.14)	(0.724)
Morality		0.020***	0.029***
		(3.661)	(6.657)
Urbanization		1.657***	1.722***
		(5.719)	(7.667)
Police		0.835	0.959
		(0.976)	(1.273)
Young		-2.482	-0.975
		(-0.578)	(-0.292)
Education		-0.904***	-0.500***
		(-5.500)	(-3.209)
GRP			-0.046
			(-1.504)
Growth			0.041
			(0.271)
Inequality			0.028
			(0.639)
Poverty			0.008***
			(5.412)
Unemployment			-0.008
			(-0.674)
Constant	1.757***	0.636	-0.084
	(27.014)	(0.588)	(-0.088)
N	208	199	199
R-sq	0.421	0.603	0.736
R-sq, adj.	0.415	0.589	0.719

Note: t statistics in parentheses, p<0.10, ** p<0.05, *** p<0.01*

Table A2. Rape estimations results.

	1	2	3
West	-0.149	-0.204**	-0.204**
	(-1.482)	(-2.069)	(-2.033)
East	0.044	-0.095	-0.142
	-0.611	(-1.023)	(-1.492)
Morality		-0.004	0.004
		(-0.562)	(0.487)
Urbanization		1.234***	1.275***
		(3.645)	(3.758)
Police		0.89	0.935
		(1.003)	(1.094)
Young		14.846***	15.334***
		(3.312)	(3.291)
Education		-0.773***	-0.448*
		(-3.517)	(-1.842)
GRP			-0.056
			(-1.271)
Growth			0.122
			(0.356)
Inequality			-0.079
			(-1.312)
Poverty			0.003*
			(1.925)
Unemployment			0.004
			(0.241)
Constant	0.725***	-2.394**	-2.223*
	-10.784	(-2.190)	(-1.744)
N	208	199	199
R-sq	0.034	0.202	0.261
R-sq, adj.	0.025	0.173	0.213

Note: t statistics in parentheses, p<0.10, ** p<0.05, *** p<0.01*

Table A3. Robbery estimations results.

	1	2	3
West	-0.251*	0.05	0.108
	(-1.890)	(0.588)	(1.424)
East	0.442***	-0.007	0.007
	(4.132)	(-0.114)	(0.122)
Morality		0.034***	0.028***
		(6.506)	(5.267)
Urbanization		0.928***	0.947***
		(3.222)	(3.336)
Police		-2.064**	-1.725*
		(-2.186)	(-1.741)
Young		11.216**	6.998*
		(2.546)	(1.661)
Education		-0.123	-0.082
		(-0.773)	(-0.433)
GRP			0.006
			(0.189)
Growth			0.237
			(0.898)
Inequality			0.066
			(1.333)
Poverty			0.004**
			(2.355)
Unemployment			-0.052***
			(-4.105)
Constant	4.011***	2.336**	2.725**
	(43.474)	(1.982)	(2.203)
N	208	199	199
R-sq	0.267	0.654	0.682
R-sq, adj.	0.26	0.642	0.662

Note: t statistics in parentheses, p<0.10, ** p<0.05, *** p<0.01*

Table A4. Drugs estimations results.

	1	2	3
West	-0.156	0.096	0.142
	(-1.507)	(0.988)	(1.623)
East	0.564***	0.169**	0.219***
	(5.969)	(2.093)	(2.696)
Morality		0.043***	0.035***
		(9.056)	(6.74)
Urbanization		0.398	0.361
		(1.163)	(1.243)
Police		-0.747*	-0.583
		(-1.854)	(-1.488)
Young		5.191	1.621
		(1.458)	(0.442)
Education		-0.103	-0.830**
		(-0.247)	(-2.085)
GRP			0.161***
			(4.279)
Growth			0.054
			(0.238)
Inequality			0.039
			(0.834)
Poverty			0.002
			(1.637)
Unemployment			-0.016
			(-1.182)
Constant	4.404***	3.112***	2.333***
	(53.597)	(4.745)	(2.877)
N	175	166	166
R-sq	0.459	0.696	0.721
R-sq, adj.	0.453	0.682	0.699

Note: t statistics in parentheses, p<0.10, ** p<0.05, *** p<0.01*

APPENDIX B

Table B1. Total crime estimation: cross-sectional OLS, 2003-2006

	2003	2004	2005	2006
West	-0.286***	-0.202***	-0.138**	-0.173***
	(-4.697)	(-3.181)	(-2.403)	(-2.970)
East	0.344***	0.417***	0.439***	0.310***
	(7.184)	(8.489)	(9.777)	(6.475)
Inequality	0.049	-0.029	0.093*	0.052
	(1.142)	(-0.831)	(1.885)	(1.408)
Unemployment	-0.004	-0.011**	-0.012**	-0.009
	(-0.659)	(-2.14)	(-2.143)	(-1.436)
Morality	0.043***	0.064***	0.029**	0.033***
	(3.282)	(4.818)	(2.434)	(2.706)
Young	0.705	-5.216**	-0.755	-0.375
	(0.269)	(-2.182)	(-0.284)	(-0.147)
Urbanization	0.002***	0.002***	0.002***	0.002***
	(3.055)	(2.637)	(2.967)	(3.199)
GRP	0.001***	0.001***	0.001	0.001***
	(3.931)	(2.974)	(1.595)	(3.513)
Education	0.000	0.004	0.009	0.012
	(-0.382)	(0.490)	(1.276)	(1.618)
Police	0.493**	0.362	-0.154	0.125
	(2.166)	(0.831)	(-0.405)	(0.359)
Constant	5.957***	7.040***	6.185***	5.933***
	(11.541)	(14.034)	(12.067)	(12.619)
R-sqr	0.411	0.422	0.420	0.350
Likelihood Ratio				

Notes: OLS: t statistics in parentheses; Spatial models: z statistics in parentheses
** p<0.10, ** p<0.05, *** p<0.01*

Table B2. Spatial Lag Model Estimations, IDM, 2003-2006

	2003	2004	2005	2006
R	0.999***	0.992***	0.993***	0.993***
	(185.44)	(179.786)	(4.384)	(208.07)
West	-0.282***	-0.202**	-0.134***	-0.173***
	(-4.467)	(-3.216)	(-2.35)	(--2.998)
East	0.351***	0.418***	0.447***	0.31***
	(7.474)	(8.581)	(9.89)	(6.53)
Inequality	0.044	-0.029	0.086*	0.051
	(1.030)	(-0.839)	(1.758)	(1.42)
Unemployment	-0.004	-0.011**	-0.011*	-0.009
	(-0.676)	(-2.163)	(-2.09)	(-1.447)
Morality	0.044***	0.064***	0.029**	0.032***
	(3.382)	(4.871)	(2.471)	(2.73)
Young	-0.414	-5.226**	-1.39	-0.375
	(1.149)	(-2.21)	(-0.51)	(-0.148)
Urbanization	0.002**	0.002**	0.002**	0.002***
	(3.182)	(2.666)	(2.808)	(3.229)
GRP	1.649***	1.172***	2.871	4.79***
	(3.944)	(3.01)	(1.568)	(3.546)
Education	-0.007	0.004	0.008	0.012
	(-0.836)	(0.496)	(1.09)	(1.633)
Police	0.439	0.363	-0.108	0.111
	(1.864)	(0.840)	(-0.286)	(0.326)
Constant	-0.609	0.288	-0.428	4.348***
	(-1.022)	(0.578)	(-0.823)	(5.378)
R-sqr	0.409	0.419	0.422	0.347
Likelihood Ratio	1.39	1.39	833.52	1.39

*Note: z statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01*

APPENDIX C

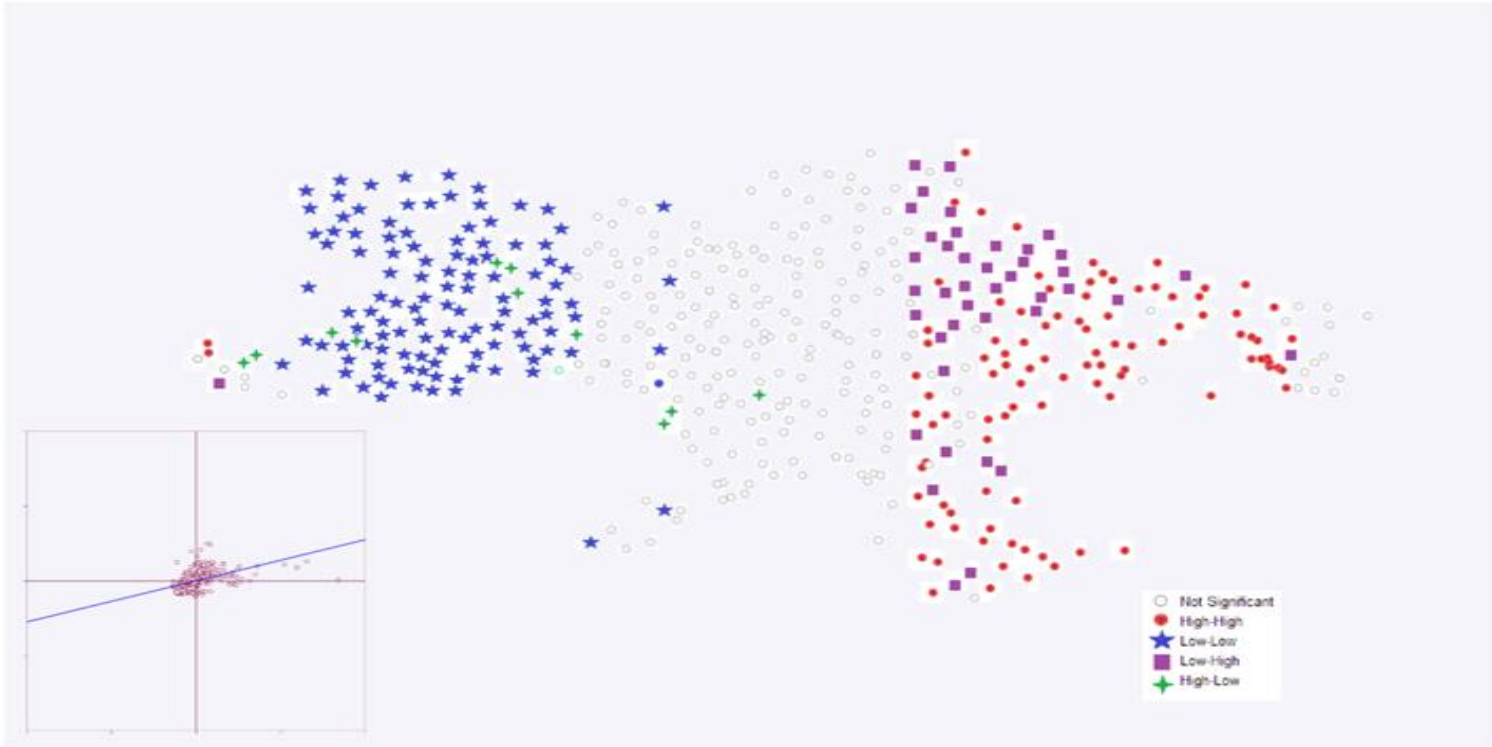

Figure C1. Total crime LISA, 2001.

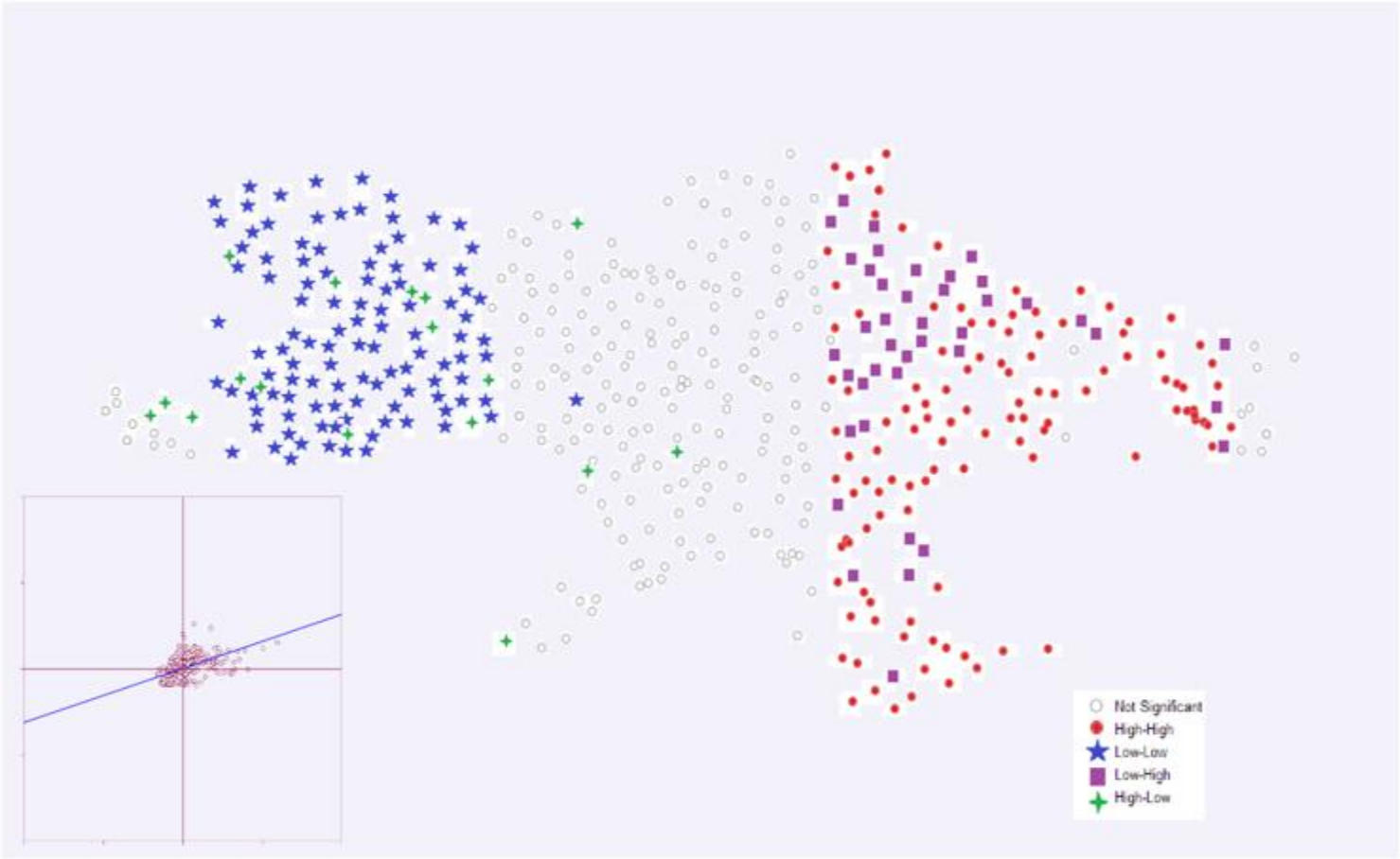

Figure C2. Total crime LISA, 2002.

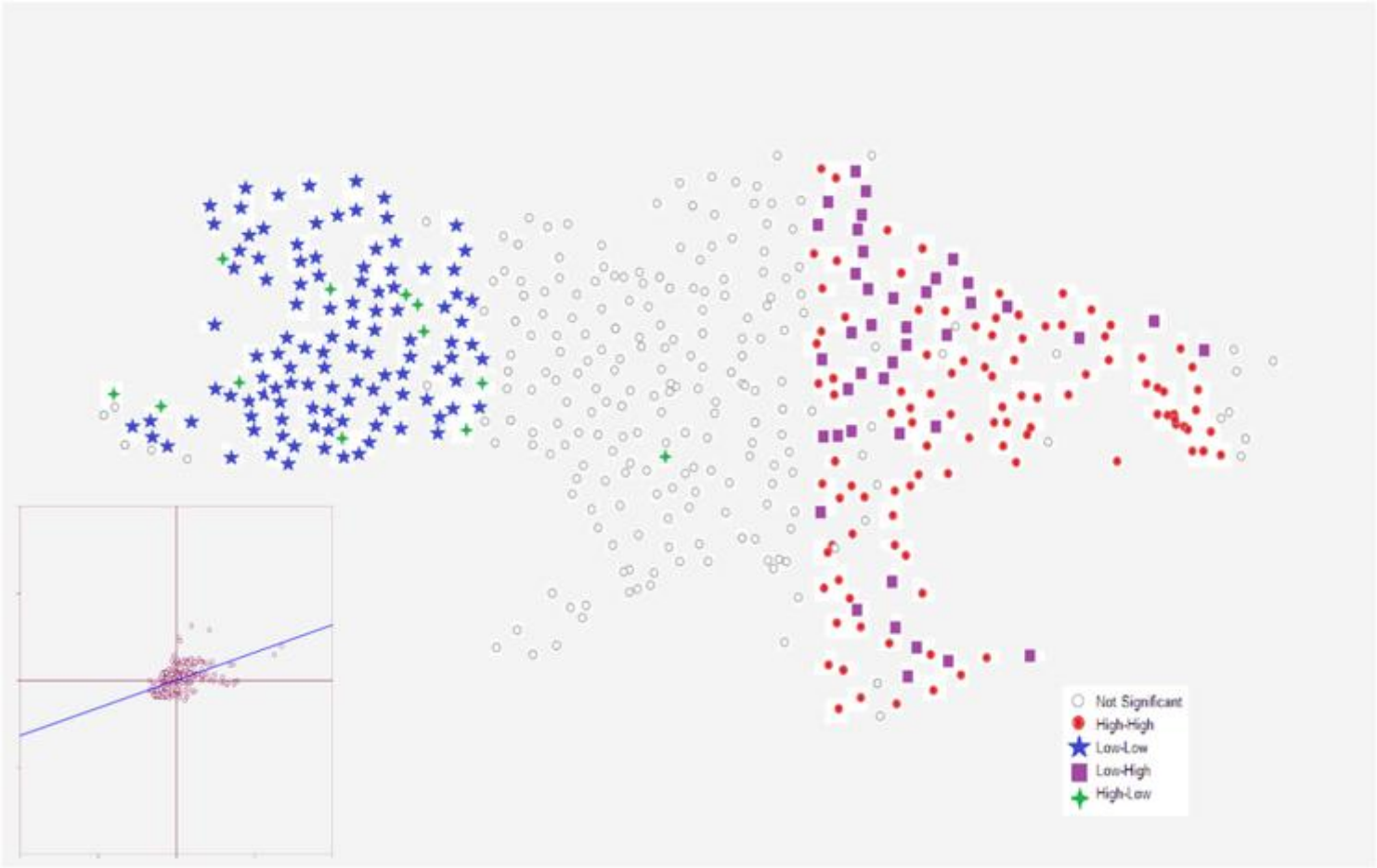

Figure C3. Total crime LISA, 2003.

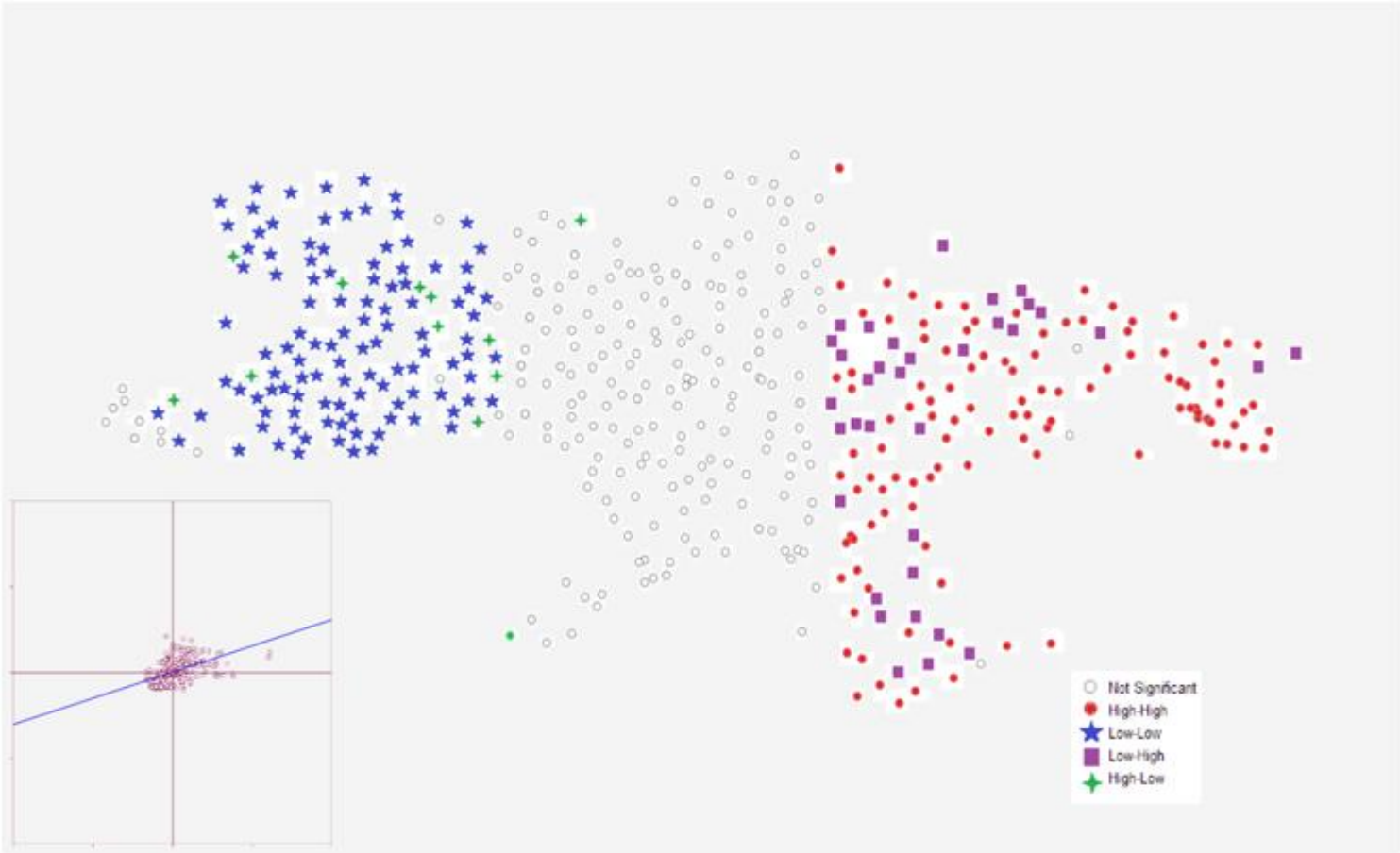

Figure C4. Total crime LISA, 2004.

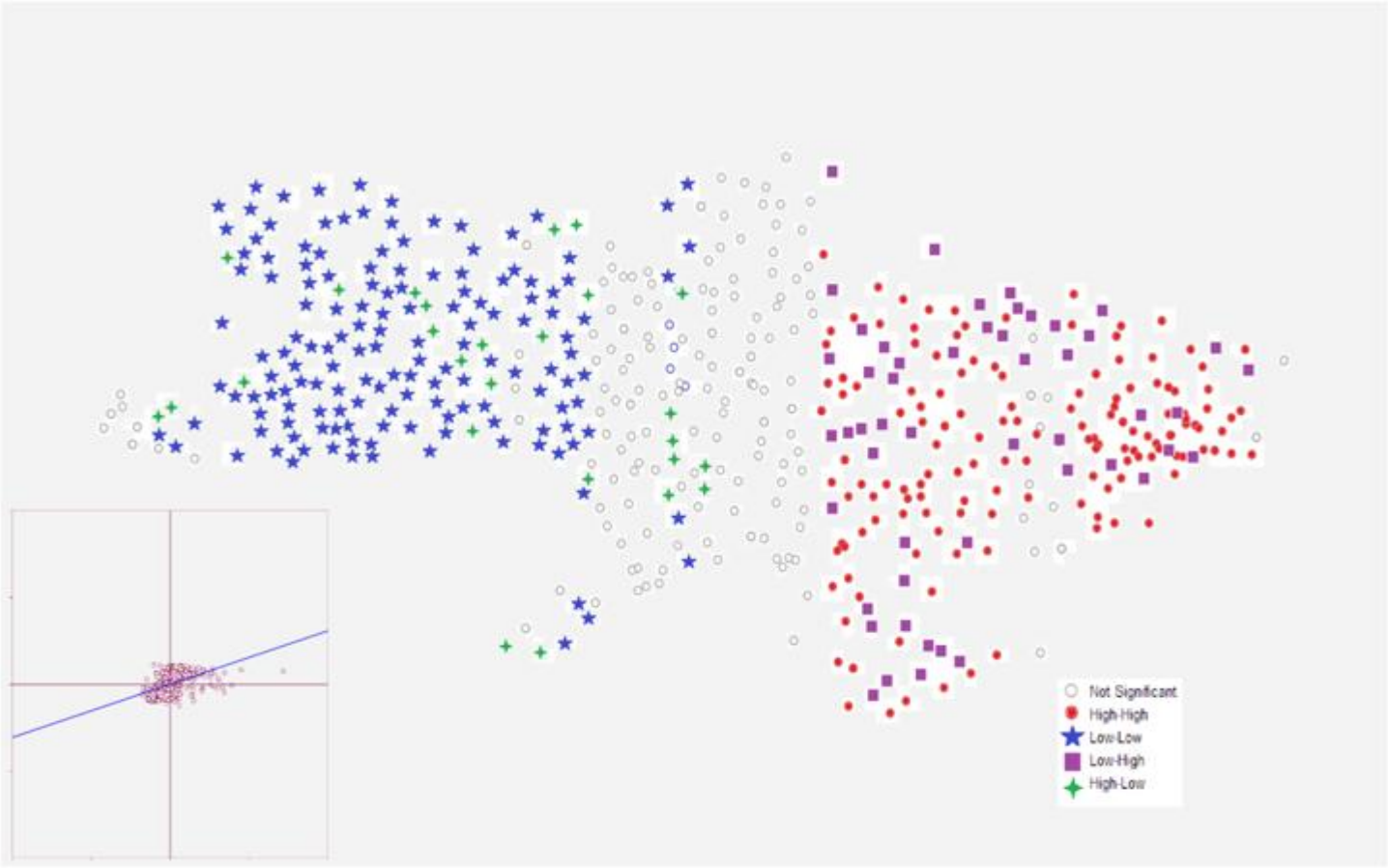

Figure C5. Total crime LISA, 2005.

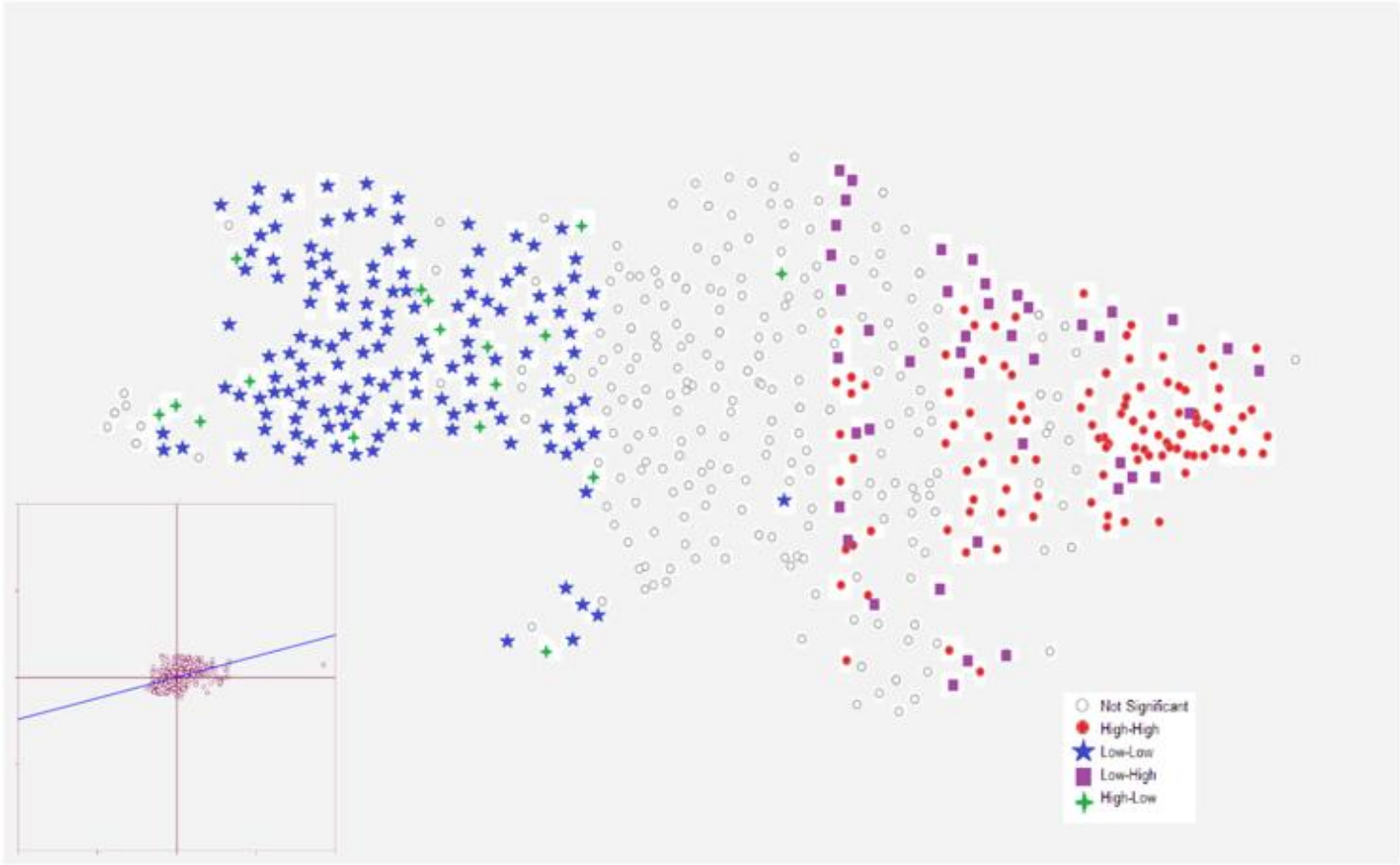

Figure C6. Total crime LISA, 2006.

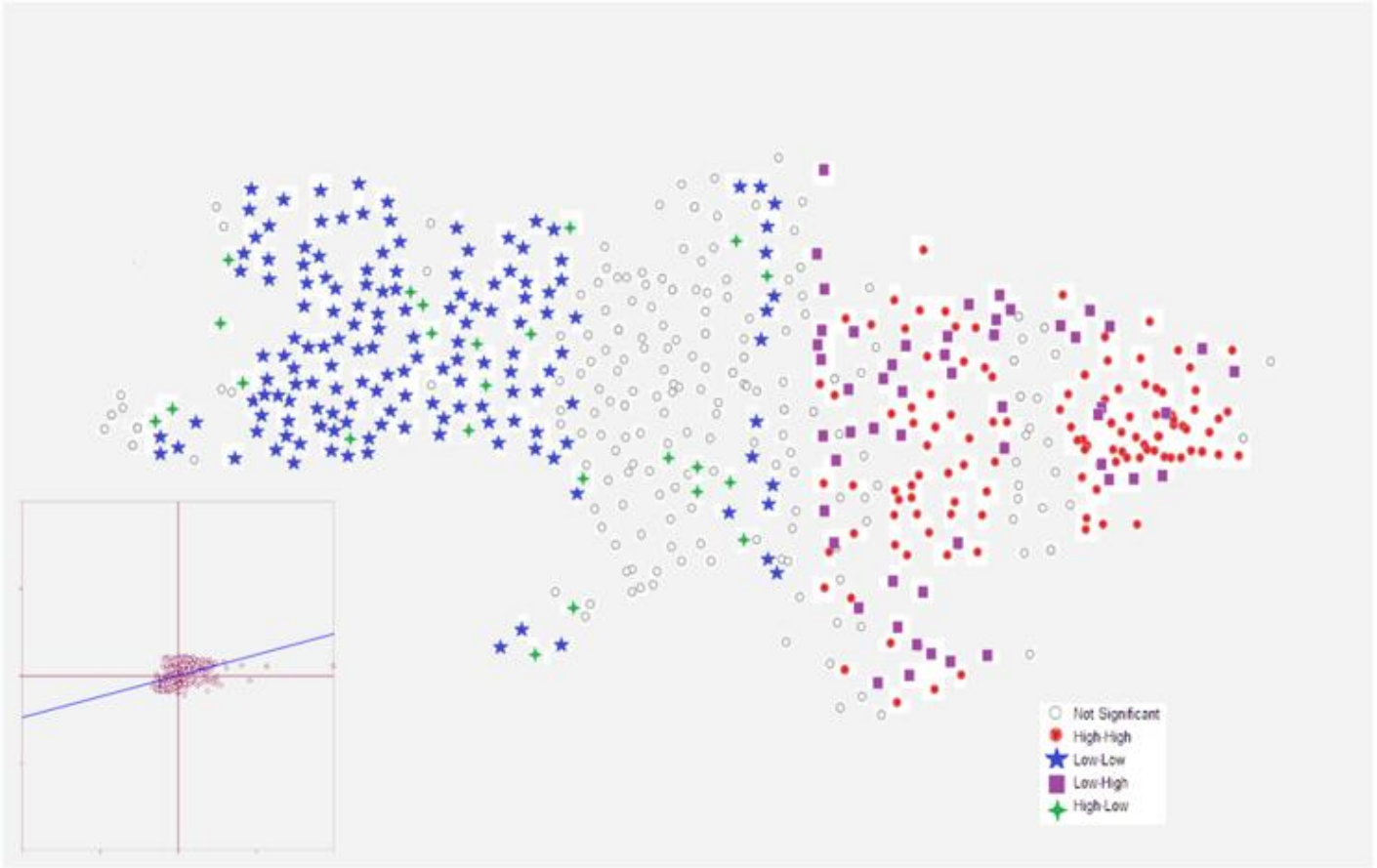

Figure C7. Total crime LISA, 2007.

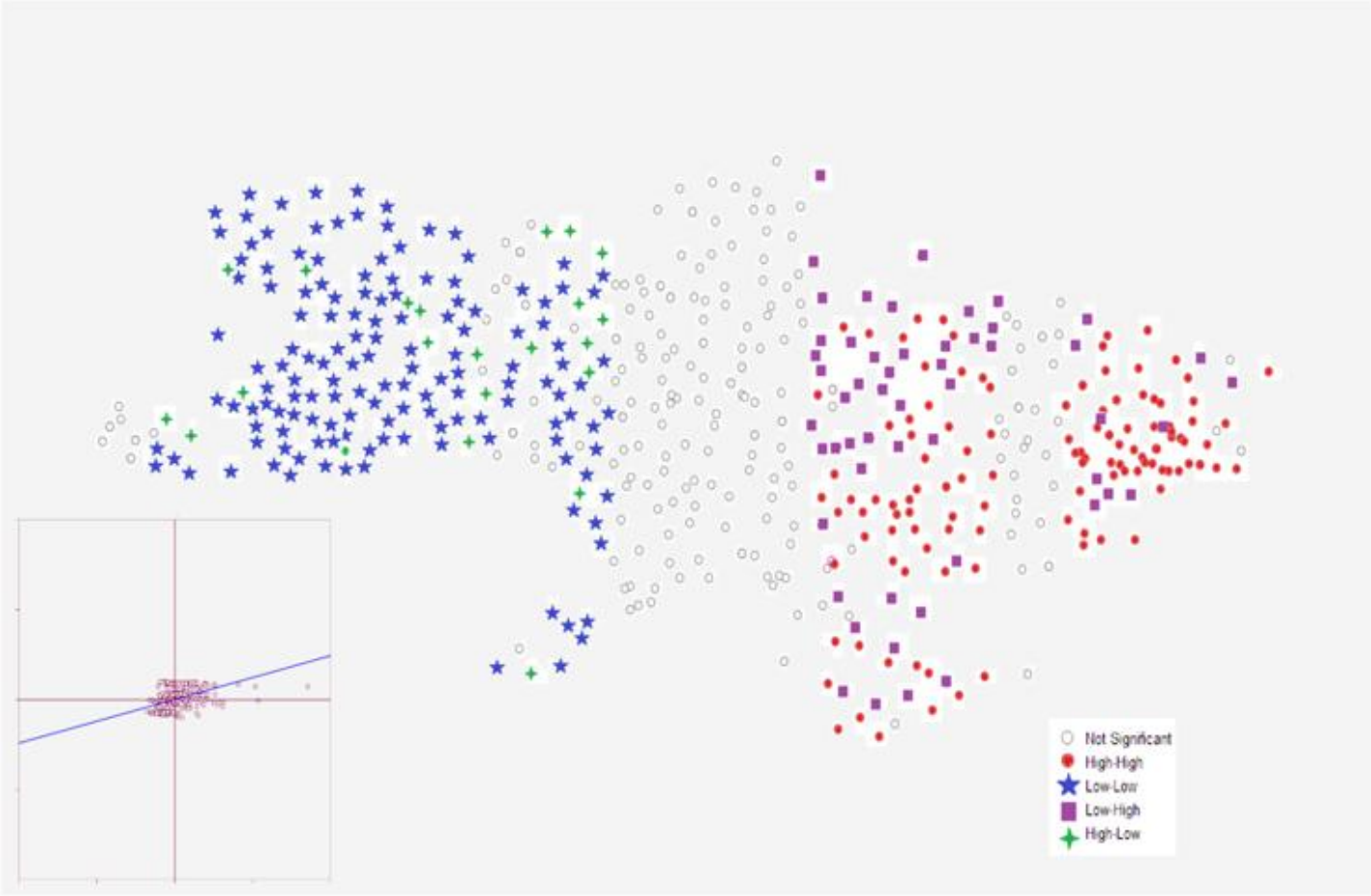

Figure C8. Total crime LISA, 2008.

APPENDIX D

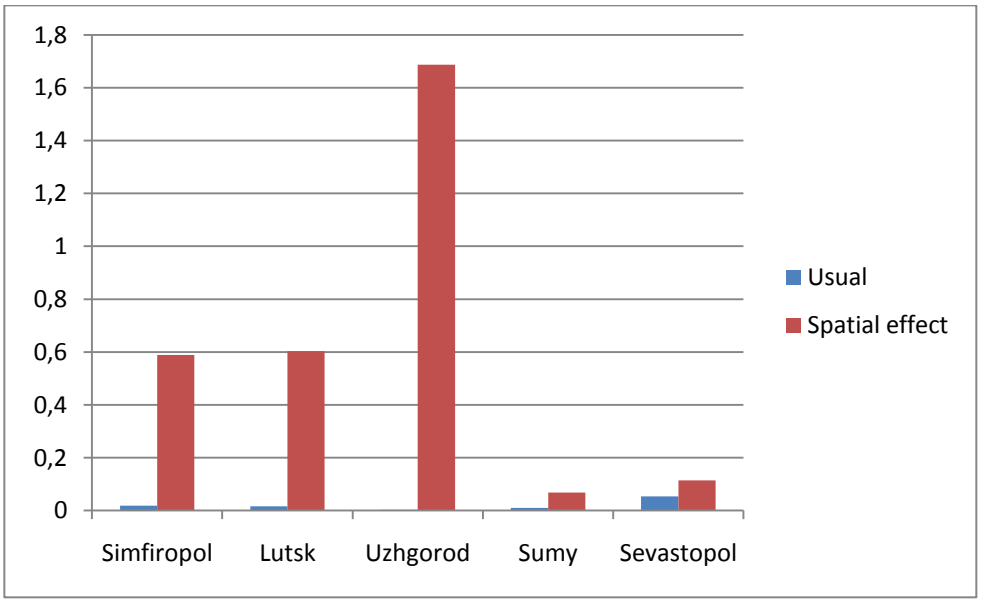

Figure D1. Spatial and usual effect of increase in urbanization

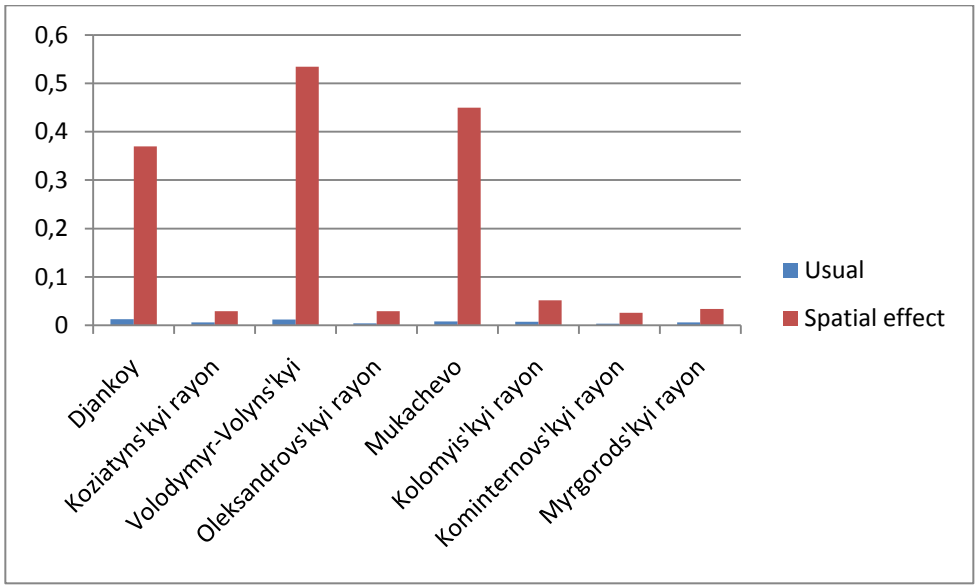

Figure D2. Spatial and usual effect of increase in income inequality