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Short and Medium term Dynamics and their Influence on Acquisitive Crime Rates in the Transition States of Estonia, Latvia and Lithuania

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Abstract The 1990s saw the three Baltic states of Estonia, Latvia and Lithuania change from centrally planned to more market oriented economies with associated societal transformations. Profound changes such as these create uncertainty and social instability that can lead to social problems including increased rates of crime and disorder. We report and comment upon Police recorded crime data that shows numbers of acquisitive and drug related crimes in the three states from 1993 to 2000. However the scale of economic change including the mediating effects of social institutions may vary from place to place within each state. Acquisitive crime is a phenomenon typical of urban or densely populated regions in the Baltic countries. Analysing regional variation in crime rates provides an opportunity to test whether negative socio-economic change impacts on rates for these crimes. Findings show weak evidence of the effect of social change on crime. Spatial statistical techniques and GIS (Geographical Information Systems) underpin the methodology employed.

Keywords Regional variation of crime · Medium and short term dynamics · GIS · Regression · Spatial statistics

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Introduction

Since the collapse of the Soviet empire (1922–1991) the Baltic States of Estonia, Latvia and Lithuania have undergone a period of profound political, economic and social change. Such change is expected to bring social problems (Durkheim 1897) including increased rates of crime and disorder (see Kornai 1990; Lotspeich 1995; Pridemore and Spivak 2003). This paper is a contribution to the growing literature on the criminological changes occurring in transition states, responding to calls by Kim and Pridemore (2005) and Liu (2005) amongst many others for more research in this area. This particular study has been made possible by better quality crime data becoming available for these three states at the regional level.

The first objective of this paper is to report changes in acquisitive crime rates (theft, car related theft and robbery) in Estonia, Latvia and Lithuania from 1993–2000 using official police data and victimization surveys. Since drug related crimes are highly correlated with property crimes (e.g., Holloway et al. 2004), they are also included. The second objective is to assess the importance of *changes* in social, economic and welfare circumstances over the period 1993 to 2000 on cross-sectional (regional scale) data on rates for the same crimes in 2000 whilst controlling for the *levels* of variables in 2000 that are expected to be significant. The "change" variables are interpreted as capturing medium-term dynamics underlying crime events. It is through these variables that the impact is measured of the transition process (social and economic change) on crime rates. The "level" variables are interpreted as capturing short-term dynamics since they refer to the same year as the regional crime data. We are particularly interested in assessing the significance of the former group of variables.

The regions used as the units of analysis are shown in Fig. 1. They are administrative units at the county level in Estonia and Latvia and municipality administrative regions in Lithuania. They are from SABE 2004 – Seamless Administrative Boundaries of Europe (Eurogeographics 2005). Their average population size in 2000 for the three Baltic countries was just under 70,000, which makes them large and rather heterogeneous spatial units. However these are the smallest units for which data are available and are smaller than those used in previous studies, for example by Kim and Pridemore (2005) who used regions in Russia with an average population size of 1,850,000.

In the following section we set the background to the study and develop a conceptual framework to help organize ideas. The "Acquisitive Crimes in the Baltic Countries: Data Issues and Crime Rate Trends" section discusses crime data availability and quality and includes a description of rates of acquisitive crimes in these countries from 1993 to 2000. The modelling work needed to meet the second objective of the paper is presented in the "Modelling Geographical Variation in Acquisitive Crime Rates" section and the "Results" section whilst the "Conclusions" section concludes the paper with a discussion of the implications of the findings and directions for future work.

Transition and its Implications for Crime Rates

There is a long tradition searching for links between crime and macro social and economic structural conditions (Durkheim 1897; Merton 1967; Polanyi 1957;

Population	Estonia	Latvia	Lithuania	Total Region
Mean	85,754.44	72,041.91	58,534.57	66,619.52
Max	400,781.00	764,329.00	558,816.00	764,329.00
Min	10,458.00	146,20.00	2,369.00	2,369.00
Median	39,429.50	43,509.00	37,817.00	40,246.00
Standard deviation	96,774.59	126,746.39	84,918.36	100,034.66
Total 2000	13,72,071.00	2,377,383.00	3,512,074.00	7,261,528.00

Fig. 1 The study area: Estonia, Latvia and Lithuania

Messner and Rosenfeld 1997; Chamlin and Cochran 1995; Savolainen 2000; Bernburg 2002). Recent studies in Russia and Eastern Europe suggest that social stress and disorganisation associated with transition from a planned to a market economy provide an explanation for increases in suicide, homicide and overall mortality (Gavrilova et al. 2000; Leon and Shkolnikov 1998; Pridemore and Spivak 2003; Stickley and Mäkinen 2005). However, for property crimes, studies that assess the impact of transition have yielded mixed results (see, e.g., Lévay 2000; Kim and Pridemore 2005; Liu 2005; also Butler 1992).

The work reported here draws on earlier work by Kim and Pridemore (2005). They followed Durkheim (1897) in arguing that citizens of countries going through profound socio-economic change experience uncertainty and instability creating anomic conditions that lead to increased rates of crime and violence. Kim and Pridemore qualified the argument by drawing on Messner and Rosenfeld's (1997) institutional anomie theory that argues that such effects are mitigated where social institutions are strong. Using data on serious property crime for Russia partitioned into 78 regions[1] they tested hypotheses on (1) the association between socio-economic change and property crime and (2) whether or not this association is mediated by the strength of non-economic social institutions (e.g., family, education and polity). Their results showed that socio-economic change (medium term post-Soviet dynamics) had no effect and that there was no support for the hypothesis that social institutions moderated the effect of structural change on robbery rates.

Estonia, Latvia and Lithuania in the 1990s

Demographically, the 1990s were marked by falls in fertility, increases in mortality and divorce rates and strong emigration. Such a trend has been associated with anomic social conditions and crime in other countries in transition (e.g., Kim and Pridemore 2005).The drop in the fertility rate was substantial in all three Baltic countries, following the same trend in other countries in Central and Eastern Europe. Philipov and Dorbritz (2003:61) list potential causes for this reduction, among them, 'emotional uncertainty, fear of the future and the dominance of dealing with everyday worries causing large sections of the population to distance themselves from binding long term decisions, such as marriage or having children'. According to Philipov and Dorbritz (2003) the rise in adult male mortality was the direct consequence of impoverishment and stress related factors leading to the adoption of unhealthy lifestyles including higher incidences of drinking and smoking (see also Ahven 2002)). A rise in infant mortality began in 1990–1991, partly because of impoverishment and worsening health care after independence and, partly (but to a lesser extent), as a result of changes in statistical definition. During the second half of the decade infant mortality began declining again (Philipov and Dorbritz 2003) but it is still high in certain regions relative to the rest of the EU (e.g., Viljandi in Estonia, Aizkraukle in Latvia, Silales in Lithuania).

[1] The average population of their regions is 1,850,000. The smallest population is 79,000, the largest 8,537,000. The standard deviation is 1,497,000 (Pridemore, personal communication).

Compared to other EU member states, divorce rates are relatively high in the Baltic countries (Eurostat 2003). Divorce rates showed a strong increase between 1990 and 2000: in Estonia, from 49 per hundred new marriages to 77 (the highest within the EU), in Latvia from 46 to 67 and in Lithuania, from 35 to 64. The highest divorce rates are found in the larger cities (e.g., Tallinn, Tartu), among ethnic Russians and in ethnically mixed families (for more details, see Philipov and Dorbritz 2003). The divorce rate, an indicator of family structure, has been suggested in previous studies as a strong predictor of offending. One of the mechanisms that links broken families to offending is the increase in poverty, particularly following a divorce (Corcoran and Chaudry 1997, Sampson 1986).

In the first half of the 1990s, the Baltic countries were characterised by strong emigration, comprising mostly ethnic Russians leaving for the Russian federation. Since then and despite some variation, Estonia, Latvia and Lithuania have continued to experience population loss due to both natural decrease and net emigration to other parts of Europe (Salt 2005). Since independence, efforts have been made to integrate the ethnic minorities remaining in these countries, but the challenges remain daunting. These overall demographic trends have reduced the population stock of the Baltic countries, have had particularly severe impacts in certain areas where population loss has been particularly marked (e.g., Ida Viru and Lääne-Viru in Estonia, Liepaja and Riga in Latvia, Rokiskis and Kaunas district in Lithuania) and had social and economic consequences (e.g., Ida-Viru and Jõgeva in Estonia, Leipaja, Tukums and Cesis districts in Latvia, Lazdijai and Panevezys in Lithuania).

Economically, the Baltic region declined in the years immediately following the collapse of the Soviet regime. Since then growth has been generally strong. Despite relatively high GDP per capita in these countries, unemployment remains high. In Latvia unemployment reached 23% of the labour force in 2000. In Lithuania, the youth unemployment rate reached 31% in 2001 with 24% in Estonia. These figures are much higher than in many other European countries (Eurostat New Cronos Database 2003). Decline in manufacturing, often associated with privatisation, combined with regional growth in the new information economy has worsened regional imbalances and as Pichler-Milanovich (1997) suggests, the most dynamic cities became attractors for investment, leaving behind those places not capable of adapting to global opportunities.

During the transition period, countries and particularly regions have differed in the way they have invested in welfare or promoted institutions concerned with the support of vulnerable social groups. Income support via welfare, such as pensions and allowances, has decreased significantly. Some areas have become more market oriented, privatising many basic services, while others have struggled to maintain their welfare system. For instance, Lithuania is characterised by low social care expenditure (15% of GDP compared to 25% to 35% in Western European countries) that is better supplied in urban areas, often reaching mostly higher income groups (Jurgelenas et al. 2005). This resource imbalance negatively affects regional welfare that might otherwise moderate negative economic-structural changes and thereby help to keep crime rates down (Pampel and Gartner 1995; Kim and Pridemore 2005).

Decline in participation rates in recent elections has also characterised the new democracies of Eastern Europe. Bernhagen and Marsh (2007) suggest that this is related to a mix of factors including a lack of political resources, deprivation, a weak political culture, and the state of civil society (Lewis 1997; Berglund et al. 2001). In

Estonia, for instance, Ida-Viru, has seen participation in parliamentary elections fall from 70.1% in 1992, to 67.2% in 1995, to 57.9% in 1999. Low participation rates in elections have also an ethnic dimension. For instance, many of the Slavs in Latvia and Estonia do not hold citizenship from their country of residence, which means that they do not have the right to vote in national elections nor to hold certain public positions. As suggested by Aasland and Flotten (2001:1024) this is already “a form of exclusion which may lead to a *feeling* of social exclusion as well”. Low participation in elections is interpreted here as a sign of weakening social bonds, a lack of engagement in the newly implemented democratic process and general mistrust in society. Crime becomes an option when ‘social bonds’ are weak and one’s connection to society fails.

A Conceptual Framework for Acquisitive Crimes

The economic conditions that often characterise the transition from a centrally planned to a market economy can engender criminal behaviour in a number of ways. Motivated offenders may have a greater incentive to act illegally because there may be a reduced risk of detection and conviction during periods of great social and political change. Individuals may act illegally because of the lack of economic opportunity and employment (Lotspeich 1995) and economic growth may create more goods to steal. A growing economy with rising levels of consumption provides more opportunities for acquisitive crime (see, for instance, Cohen and Felson 1979). In the Baltic countries, stocks of goods rose in the 1990s. Just after independence, wealthier individuals travelled to the West and acquired Western goods (Iwaskiw 1996). Today property crimes are fed by the constantly increasing amount and variety of goods available in the Baltic countries themselves. In brief: the opportunities for acquisitive crimes and the supply of motivated offenders may both increase during periods of economic growth particularly if that growth is geographically and sectorally uneven.

Evidence suggests that motivated offenders are most motivated to commit offences within a social context where there is an unequal distribution of material resources and where there is an absence of pro-social oriented institutions (Pampel and Gartner 1995; Messner and Rosenfeld 1997). The literature on social cohesion has long suggested the importance of social institutions in moderating the negative effects of economic-structural problems in a society that might otherwise be associated with higher rates of offending (Sampson 1986; Chamlin and Cochran 1995).

Differences in life styles, lack of citizenship and long term socio-economic marginalisation of certain ethnic groups in the Baltic countries (e.g., Slavic minorities in Latvia and Estonia; Aasland and Flotten 2001), have historically generated particular propensities to offend (e.g., Russians and violent crime in Estonia; Lehti 2001). According to police statistics, the violent criminality of the non-Estonian (mainly Russian) population has been higher than the Estonian population for several decades. People of non-Estonian origin who have comprised about one third of the population since the 1970s, have consistently committed about two-thirds of all homicides. According to police data, in 2005, people without

Estonian citizenship (18 % of the total population) committed 43 % of all solved homicides. Although this tendency also appears in the homicide survey (Lehti 2001) and was also confirmed by interviews with experts, comparisons should be interpreted with caution. One reason is that this overrepresentation of ethnic minorities as offenders is less pronounced in Lithuania. In 2000, 28 % of suspects involved in homicides were ethnic minorities (the proportion of ethnic minorities in Lithuania was 17 % of the whole population in the same year).

Political borders and the areas close to them are unique places for criminal activity (Ceccato and Haining 2004; Ceccato 2007). The three Baltic states, as part of the new EU borders, play an important role as attractors and transit territories for international organised crime (Ulrich 1994; Persson 1999; NCPD and Danish police 2002). This role is enhanced by the geographical location of the three countries and their "propensity to corruption"[2]. Organised crime groups are involved in trafficking different goods, including illegal weapons, stolen vehicles and contraband products such as cigarettes, clothes, furniture, counterfeit money and illegal immigrants (Europol 2004). Changes in crime levels are dependent on changes in the nature of law enforcement and offence classification (e.g., penal code definitions), police practices and organisation, changes in the resources available to fight crime and perhaps most importantly, the ability of criminal systems to adjust (Lotspeich 1995).

We argue that geographical variation in the rates of acquisitive crimes in a given period of time is explained by short term economic conditions; social composition (demographic structure) and the social context (strength of social institutions; quality of welfare provision). We also argue that the medium term (post Soviet) dynamics of these factors may also be important in explaining offence rates. Indeed we are specifically interested in this latter hypothesis and specifically in terms of economic *change*, social *change* and welfare *change*. In testing these hypotheses our modelling strategy will be to include both groups of variables and to allow for national differences in the way offence rates respond to each of the factors. Figure 2 provides a schematic representation of our framework where the lines and arrows indicate the existence and direction of association.

Acquisitive Crimes in the Baltic countries: Data Issues and Crime Rate Trends

One of the most common problems when comparing crime statistics in Europe is the difference in crime definitions between states. According to Gruszcynska and Gruszczynska (2004) European crime statistics are as yet not subject to recommendations on the unification of rules for data collection, processing methods or analytical procedures. Each European country uses its own system of definitions, with distinct rules for collecting data. For a discussion of the common problems with

[2] Since its creation in 1995, the Corruption Perception Index has sought to quantify the perception of business people and country analysts of the degree of corruption in a country. From 1998 to 2006 the score of Baltic countries has improved but still ranks relatively low (in 2006: Estonia 6.7, Latvia 4.7 and Lithuania 4.8; where 10 is highly clean and 0 is highly corrupt) in comparison with their Scandinavian neighbours (Transparency International 2007).

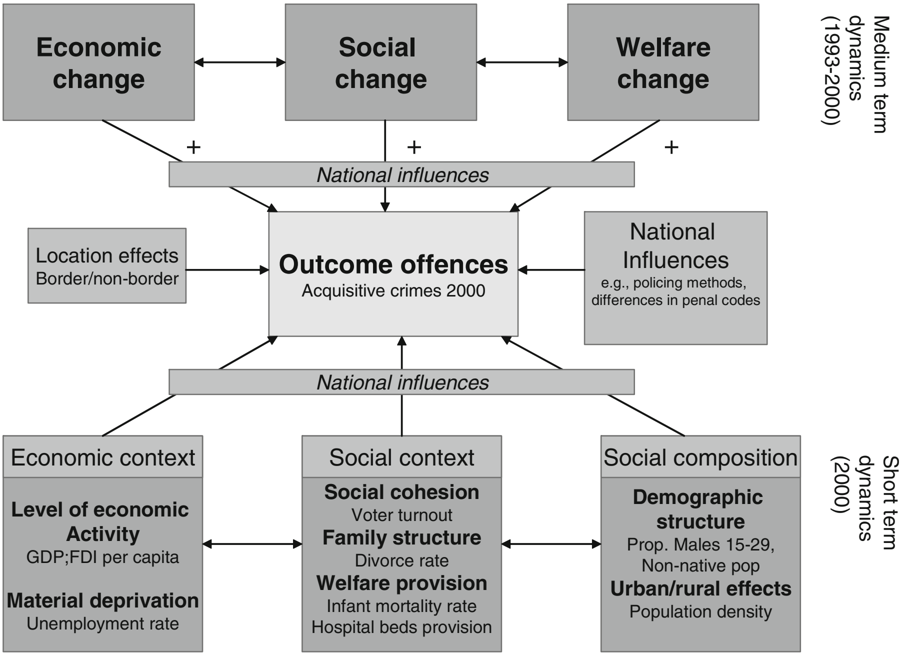


Fig. 2 The conceptual framework

police recorded data, see *European Sourcebook of Crime and Criminal Justice Statistics* (1996, 2003). The implication of this is that certain countries might have more crimes (and more crimes of particular types) just because of their penal codes and their system of classification.

Another common problem with crime data is under-reporting. According to the International Crime Victimisation Survey – ICVS (del Frate and Van Kesteren 2004) the percentage of crime events reported to the police has been considerably lower in Central and Eastern European countries than in Western Europe. Differences in theft rates between Baltic countries and Western Europe are partially explained by different reporting practices. Crimes such as drug related crimes began to be better reported in Estonia, Latvia and Lithuania in the 1990s. This will have contributed to the significant increase in these rates (Fig. 3).

In the case of the Baltic countries, crime records are influenced by political and administrative changes in these countries, and by changes in the criminal code and police practices, including the presence or otherwise of corruption. Most of the major systematic changes are well known (e.g. changes to the penal code and in recording systems) but the difficult part is to estimate how minor (perhaps local) changes have affected levels of recording. For example, although all police authorities should follow standardised forms, modifications to municipal boundaries (prior to EU membership) might have had an unexpected effect in the way crime was recoded in those affected regions. In order to ensure comparability of offence data across the three different countries, experts from each country were invited to modify crime definitions of the selected offences (initially based on the European

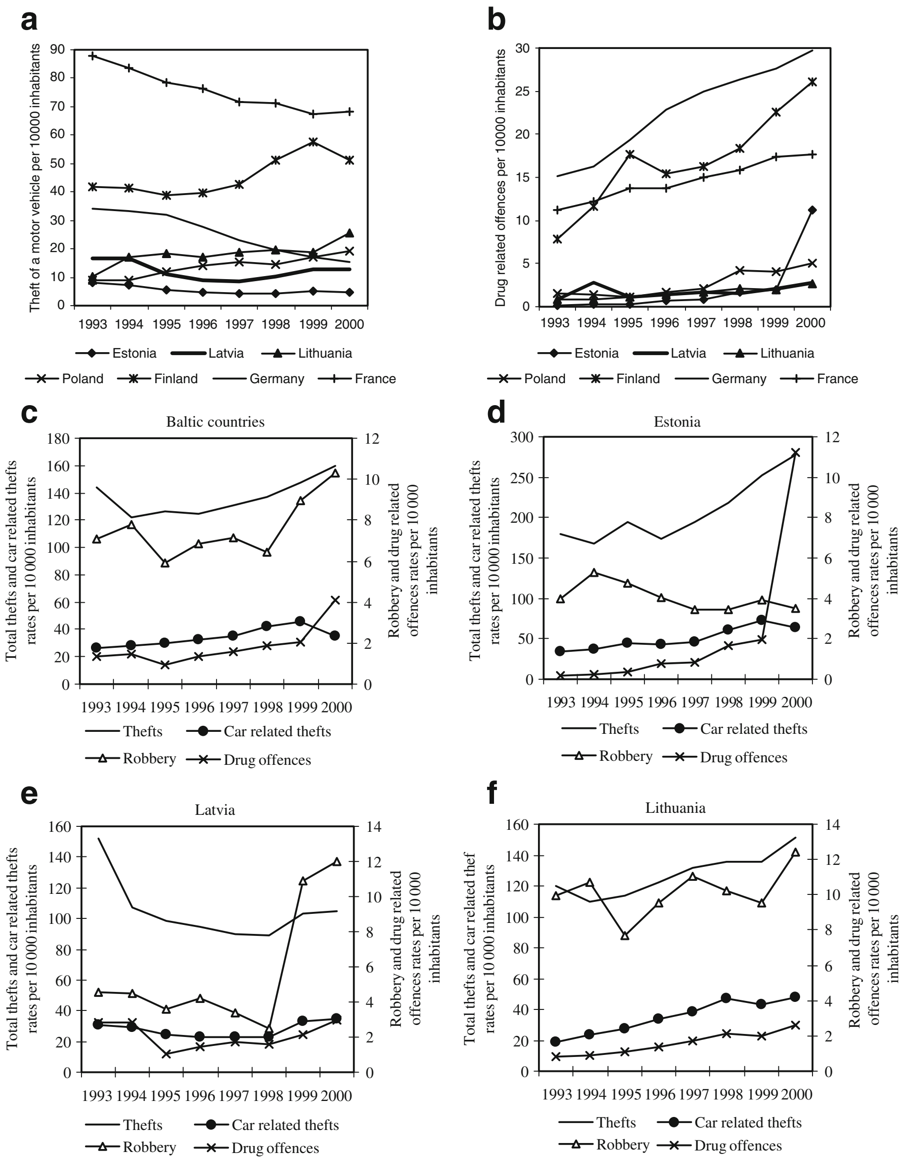


Fig. 3 Theft of a motor vehicle (a) and Drug related crimes (b): Baltic countries in relation to selected European countries. (c–f) Acquisitive crime rates in Baltic countries, 1993–2000. (c) Baltic countries (d) Estonia (e) Latvia (f) Lithuania

Sourcebook of Crime and Criminal Justice Statistics) according to the local penal codes. Data for this study were then requested based on crime definitions that were provided by these experts. A survey was also performed with a small group of professionals dealing with crime data (the questionnaire used in this survey is available on request). Fourteen experts[3] answered the questionnaire, which included questions on availability and quality of data from the early 1990s to the present and from the small area to the national level, changes in penal code, police organization, processes of data gathering and systematization, and boundary/administrative changes in police units over time. For an extensive discussion of the results of the survey, see Ceccato (2008)[4].

Demographic and socio-economic data used in this analysis are comparable. Data collection, according to the three National Statistical Bureaux has been in accordance with international standard definitions and practices of data collection and systematisation (e.g., EUROSTAT) from the early years since independence. Only in three cases were data not fully comparable. In Estonia, GDP per capita was available for NUTs-3 only while for Latvia and Lithuania, data were available for municipalities. Estonia had no data for Foreign Direct Investment, which therefore had to be estimated[5]. Voter turn out data for Lithuania also had some areas with a slightly different shape (voting districts) when compared with the ones used in this study. The GIS polygon-split tool was used to associate new attribute values for these zones using the area weighting criterion. We now turn to a discussion of trends in crime levels in the Baltic countries.

Although all acquisitive crimes increased significantly in the Baltic countries between 1993 and 2000 according to official statistics, no significant changes were found in the levels and composition of offences declared by victims in the same period. Ahven (2004) compared trends in police records of crime in the second half of the 1990s with survey data for the Baltic countries from two sources: the International Crime Victimisation Survey (ICVS) and Living Conditions Surveys (LCS)[6]. A possible cause of this is the growth in crime reporting to police in the Baltic countries. In Finland, for instance, the long-term growth of the crime reporting rate was coincident with an increase in the fear of crime, an increase in the average age of the population, on-going urbanization and the gradual improvement of the availability of police services (Heiskanen et al. 2004:24). Previous studies in Great Britain, the United States and elsewhere, suggest that differences between recorded crime data and the results of victimisation surveys may be the result of changes in the socio-economic composition of the victims of crime (see, for instance, Trickett et al. 1995, Levitt 1999, Young and Mathews 2003, Nilsson and Estrada 2006). With

[3] A list of the experts who participated in this survey is shown at http://www.infra.kth.se/sp/Research/Transition/analytic1.htm

[4] Another factor that also may have affected crime rates in the Baltic countries is that the total population in these countries decreased during this period. Since crime rates are often calculated based on resident population, certain regions might have reached a peak when natural increase was negative and out migration positive.

[5] Estonia had missing data on foreign direct investment. Missing values were replaced by using other regressors in the model as instrumental variables, as suggested by Pindyck and Rubinfeld 1998; Kim and Pridemore 2005. The variable with the missing observation was regressed on all other independent variables that had complete data (index of social change for Lithuania and Latvia and Index of welfare change for Lithuania and Latvia) and used the predicted values to replace the missing data.

[6] International Crime Victimisation Survey (ICVS) were carried out in Estonia in 1993, 1995 and 2000; in Latvia (Riga region) in 1996, 1998 and 2000; in Lithuania (Vilnius) in 1997 and 2000. Living Conditions Surveys (LCS) were performed in all Baltic countries in 1994 and 1999.

an increasing polarisation between different groups in society, a larger proportion of those victimized came from the poorer socio-economic groups. For the Baltic countries however such inequality in victimisation cannot be tested since socio-economic data from victimisation surveys are too limited to carry out meaningful analyses.

In this analysis, we focus on police recorded data from 1993 to 2000. Before 1993 it is difficult to be certain that the data hold their quality over time because of official interference (Butler 1992, Lehti 2001, Gruszczynska and Gruszczynska 2004). After 2000, penal code and territorial changes in these countries have affected the way offences are recorded (Ceccato 2008).

Since the mid 1990s, crime rates in the Baltic countries have tended to become more like those found in Western European countries. Theft rates increased about 10%, thefts of motor vehicles by 30%, but both these rates are still lower than in Western Europe (Fig. 3a where theft tended to decrease during the same period, particularly in Germany and France[7]). All acquisitive crimes increased in the Baltic countries between 1993 and 2000 (Fig. 3c). However there were differences between the three countries (Fig. 3d–f). Two non-parametric statistical tests based on the rank order of the data were used to test for the statistical significance of these differences. Kruskal–Wallis was used to test for differences in the levels of selected offences by year and country; the Mann–Whitney U test was used for pair wise comparisons between countries. All offences showed significant differences (p=0.05) between 1993 and 2000 for all countries. The exceptions were robbery that showed a significant difference between 1995 and 2000 and total thefts for which the difference was significant between 1996 and 2000.

There were some quite marked differences between the three countries. Robbery rates went down in Estonia after 1994 – see Fig. 3d; fluctuated in Lithuania – see Fig. 3f; in Latvia the rate shot up between 1998 and 1999 and held at the higher level in 2000 – see Fig. 3e. According to Gruszcynska and Gruszcynska (2004) robbery rates do not differ much in Central and Eastern Europe from Western Europe[8].

Drug related offence rates were generally much lower in the Baltic States than in Western European countries (Fig. 3b) and varied widely across the Baltic states in 2000, varying from an average of over 11 per 10,000 in Estonia to around 2.6 in Lithuania. Such large differences (within the Baltic states and with Scandinavian countries) must be at least partly due to factors such as differences in penal codes, differences in the way crime is recorded, differences in criminal policy and in police practices between countries. In the Baltic States, drug related offences increased nearly 300% between 1993 and 2000, Estonia having apparently the largest increase (from 0.2 to 11.2 per 10,000 inhabitants).

There is also evidence of differences in rates of acquisitive crimes *within* each of the Baltic countries in 2000 (Table 1). Crime definitions here are based on the European sourcebook of crime and criminal justice statistics, 2003 and local penal codes (see Table 4 for details).

In Estonia, for instance, Tallinn has had the highest crime rates and the islands of Western Estonia (Saaremaa and Hiiumaa) have had the lowest crime rates since the

[7] Crime data comparison using data from the Estonian Police Board, Latvia's Ministry of Interior, Lithuania's Ministry of Interior, Home Office (2003), European Sourcebook of Crime and Criminal Justice Statistics (1996, 2003) and population data: UNECE (2002) available at http://w3.unece.org/pxweb/Dialog/.

Table 1 Intra-country crime rate variation (per 10,000 inhabitants) 2000

	Theft	Car related theft	Robbery	Drugs
Estonia				
Mean	204.49	32.68	1.64	5.68
Median	221.77	30.18	1.07	1.75
Max	420.98	134.11	7.76	19.31
Min	61.10	4.78	0.27	0.35
Standard Deviation	88.17	30.08	1.89	11.42
Latvia				
Mean	78.86	18.47	4.57	1.55
Median	72.26	16.57	2.77	0.56
Max	155.79	62.55	22.63	12.89
Min	43.08	3.48	0.00	0.00
Standard Deviation	26.57	12.87	4.45	2.75
Lithuania				
Mean	125.66	34.15	7.14	1.59
Median	124.76	23.24	5.35	0.85
Max	447.63	190.12	39.95	11.89
Min	50.54	7.84	0.00	0.00
Standard Deviation	60.32	30.56	6.65	2.21

early 1990s (similar to Western European countries). The high level of crime in Tallinn is attributable mainly to the large number of thefts (particularly thefts from vehicles). In rural areas, the number of thefts has been largest in the vacation areas of Harju and Ida-Viru. Drug-related crime, which has been increasing since the end of the 1990s, was first recorded only in Tallinn and in Ida-Viru; in recent years, it has spread to other regions, affecting, in particular, urban areas. For an overview of overall crime levels and patterns in Estonia, see Saar et al. (2003) and Lehti (2001). In Latvia, Riga including Jurmala, displayed high crime rates in the 1990s. Other urban areas, such as Daugavpils, Jelgava, Liepaja, Rezekne, Ventspils have also had high crime rates, particularly property and drug related crimes. As in Estonia and Latvia, crime is more widespread in urban than in rural areas in Lithuania. Vilnius, Kaunas and Klaipeda, the three major urban areas, had on average a 48% increase whilst their neighbouring ‘less urban’ district municipalities had only an 11% increase. These three municipalities are densely populated and relatively affluent. In Lithuania, regions that experienced higher increases in registered offences were the border regions of Visaginas and Mazeikiai, followed by Telsiai and Birstonas.

We turn in the next section to reporting the results of using the data on regional variation in crime rates in 2000 to test the hypotheses set out in the early part of the paper.

Modelling Geographical Variation in Acquisitive Crime Rates

Modelling was undertaken combining the three countries into $n=107$ administrative areas[8]. We expect pooling data to produce more reliable estimates of the signs of the regression coefficients and more powerful tests of hypothesis by creating greater

[8] Because the Estonian islands are physically separated from the mainland and historically have had a different crime history, they were excluded from the analysis.

variation in the independent variables. Both Estonia and Latvia have relatively few administrative areas making tests of hypothesis difficult if these countries are handled separately. To make some allowance for national differences between the three countries in policing methods and offence classifications, dummy variables were included on the intercept coefficient (β_0) corresponding to the constant term. To allow for national differences influencing how the independent variables impacted on the dependent variable, dummy variables were also included on the K regression coefficients (β_1, β_2,……,β_K) corresponding to the K independent variables (X_1, X_2,….,X_K).

The first phase of modelling used offence counts as the dependent variables in four separate negative binomial regressions. For a review of the case for using this model for analysing offence rates see Osgood (2000) and Osgood and Chambers (2000). Let λ_i denote the expected number of offences of a particular type in administrative area i and let n_i denote the population at risk in area i (i=1,…,107). Then λ_i/n_i is the per capita crime rate. We assume therefore that the observed count follows a negative binomial probability distribution and that (for i=1,…,n):

$$Ln[\lambda_i] = Ln[n_i] + \beta_0 + \beta_{0,1}D_{1,i} + \beta_{0,2}D_{2,i} + \sum_{k=1}^{K}\beta_k X_{k,i} + \sum_{k=1}^{K}\beta_{k,1}D_{1,i}X_{k,i} + \sum_{k=1}^{K}\beta_{k,2}D_{2,i}X_{k,i} \qquad (1)$$

where Ln[.] denotes the logarithm to the base e;

D_1=Estonia dummy. $D_{1,i}$=1 if the ith area is in Estonia; 0 otherwise;

D_2=Latvia dummy. $D_{2,i}$=1 if the ith area is in Latvia; 0 otherwise.

Ln[n_i] is called the offset variable. Its regression coefficient is fixed at one. $D_{1,i}X_{k,i}$ is the product of X_k for the ith area and the Estonia dummy. It will be $X_{k,i}$ if area i is in Estonia and 0 if area i is not in Estonia. The other terms follow in the same way. So the intercept coefficient for Lithuania is β_0, for Estonia it is ($\beta_0+\beta_{0,1}$) and for Latvia it is ($\beta_0+\beta_{0,2}$). The regression coefficient for X_k (k=1,…, K) for Lithuania is (β_k); for Estonia it is ($\beta_k+\beta_{k,1}$) and for Latvia it is ($\beta_k+\beta_{k,2}$).

The negative binomial model is particularly suited to the case of small counts, particularly where some counts are zero as here in the case of robbery and drug related offences. In these circumstances it is to be preferred to using Ln[λ_i/n_i] in a (log) normal linear regression model, since 0 counts need to be increased by an arbitrary constant and the distribution of rates is likely to be right skewed (there is a lower bound of 0 on counts but no upper bound) and discrete (unit increases or decreases in a count do not produce a smooth, continuous shift in the value of the dependent variable). In addition since offence rates calculated for large populations have a smaller sampling variance than rates calculated for small populations, error variances may not be constant across the set of administrative areas thus violating another of the statistical assumptions of the normal linear regression model. The Poisson model (to which the negative binomial model is related) also solves the problem of heteroskedasticity of error variance which is most in evidence if there are many administrative units with greatly varying populations. However because of intra-area heterogeneity of risk, overdispersion is often encountered when modelling counts for geographical areas (the Poisson model assumes that the mean and variance of the dependent variable are equal) which undermines inference with this model by underestimating the sampling variances of the estimates of the regression coefficients.

A problem with the negative binomial model when applied to spatial data arises if model residuals are spatially autocorrelated and this autocorrelation cannot be eliminated by the inclusion of additional, statistically significant, independent variables. In the presence of residual spatial autocorrelation, type I errors are inflated. It is therefore essential to test for residual spatial autocorrelation by calculating the Pearson residuals and implementing an appropriate statistical test. We implement the Moran I test on the Pearson residuals following a procedure recommended by Lin and Zhang (2007). The Moran test requires the definition of a "connectivity" or "weights" matrix that defines the spatial relationships between areas. Throughout this study an administrative area, j, is a "neighbour" of i (N(i)), if j shares a common boundary with i and is in the same country. The binary (0,1) matrix that is created by this pseudo-ordering is then row standardized by dividing each entry on a row (i) by the row sum (i.e. the number of neighbours of i). In situations where the test rejects the null hypothesis of no spatial autocorrelation, the analyst needs to assess whether there is a case for fitting a normal model to the logarithm of the crime rates because for a normal variable there are modelling tools available to cope with the effects of spatial autocorrelation. We shall return to this issue in the next sections.

Two distinct sets of independent variables were used in this study: indexes to account for regional variations in economic, social and welfare *change* and variables measuring regional variations in the *levels* of attributes in 2000. Given the results of previous research in this area we are particularly interested in the significance, or otherwise, of the change variables.

Economic conditions in 2000 are measured using the unemployment rate, GDP per capita and foreign direct investment per capita. The social context in 2000 was measured using the divorce rate and voter turnout in Parliamentary elections as measures of the strength of family structures and social cohesion; infant death and hospital bed provision rates are used as measures of the quality of welfare provision. Social composition in 2000 was measured by calculating the proportion of males in the population aged 15–29 and the proportion of non-natives. The rate of natural increase and net migration were also calculated as indicative of social and economic conditions. In order to capture urban effects we included a measure of population density and also included a dummy to identify border areas. For some areas and variables data were not available for the year 2000 so nearby years had to be used instead.

Economic change is measured by summing the values of two standardised variables (mean zero and standard deviation one): per annum change in unemployment and per annum change in Foreign Direct Investment (FDI). As the index for economic change increases, change is for the worst (more unemployment and/or less FDI relative to the average change) but since it is a composite index it measures the net shift. A large standardised increase in one could offset an improvement in the other. The measure of social change is the per annum change in the divorce rate. The measure of welfare change is also a sum of standardised variables: the per annum change in the number of deaths of children under 1 years of age per 1000 live births plus the per annum change in the number of hospital beds per 1000 inhabitants. The index was constructed so that as the welfare change index increased the change was for the worst (more deaths and/or fewer beds relative to the average change). Because of data availability, change calculations could not always use the same years. Details of these calculations are given in the Appendix.

Whether used for calculating rates or defining the offset in a negative binomial model the choice of the population at risk will have an effect on results. Throughout we use the total population as the measure of the population at risk. Two problems arise with this choice. First, resident population might not be a good denominator for an offence like car thefts since the population at risk is the total number of "car hours" in the streets over a given period of time (for which data are not available) and this need not be a simple function of the total population. Second capital cities and places such as holiday resorts receive a significant flow of temporary population in certain periods of the year.

The list of dependent and independent variables and the years for which data were available are summarised in Table 5 together with their descriptive statistics.

Results

Results obtained from fitting the negative binomial model to the four offences are summarized in Table 2. We report the most acceptable model obtained by maximum likelihood estimation using STATA. An acceptable model is defined in empirical terms as we do not consider that this area of research is sufficiently developed theoretically nor the data complete and of sufficient quality in relation to our conceptual framework to justify retaining non-significant variables in the final model purely on theoretical grounds. So our definition of an acceptable model is one where only statistically significant independent variables are retained; the goodness of fit measure confirms the model has explanatory power and the regression diagnostics confirm that statistical and data assumptions have been satisfied for the purpose of hypothesis testing.

Per capita rates of drug related offences are higher in areas with larger proportions of non-natives and higher population densities and in areas with lower levels of GDP per capita and, in Latvia, with lower infant death rates. Drug offending seems therefore to be associated with urban areas, areas with large proportions of non-natives and areas with relatively low levels of economic activity. Where these circumstances combine then particularly high rates of drug offending are to be expected (for instance, in Estonia, Ida Viru region, in Latvia, Rezekne city and in Lithuania, Jelgava city). We should not, of course, draw the conclusion that it is the non-native population that is most responsible for drug offending because this is an ecological analysis. However having large numbers of non-natives in an area may create problems of communication, animosity and mistrust and hence problems of social disorganization (Bursik and Grasmick 1993). The relationship with the infant death rate is not easily interpreted and seems to run counter to expectation but may reflect the take up of recreational drugs in areas of relative affluence. The model has relatively low explanatory power – the lowest of all the four offences considered

Table 2 Results from fitting a negative binomial model to offence counts with the log of the population at risk as the offset

Independent variables	Theft	Car related thefts	Robbery	Drug related
Medium term dynamics				
Social change: β		−3.615		
se[β]		1.235		
prob		0.003		
Social change: β		6.102		
[Latvia] se[β]		1.963		
prob		0.002		
Short term dynamics				
Divorce rate: β		0.478	0.418	
se[β]		0.132	0.149	
prob		0.000	0.005	
Non-native: β				0.030
se[β]				0.005
prob				0.000
GDP: β				−0.0003
se[β]				0.0001
prob				0.002
GDP [Estonia]:β	0.0002			
se[β]	0.0000			
prob	0.041			
Voter turnout: β			−0.022	
[Estonia] se[β]			0.005	
prob			0.000	
Infant death rate: β				−0.120
[Latvia] se[β]				0.023
prob				0.000
Other variables				
Population: β			0.0003	0.0004
Density se[β]			0.0001	0.0001
prob			0.043	0.002
Latvia:β	−0.501			
[Dummy] se[β]	0.217			
prob	0.021			
Constant: β	−4.342	−7.031	−8.680	−8.202
se[β]	0.129	0.368	0.383	0.331
prob	0.000	0.000	0.000	0.000
Log Likelihoods[a]				
Null model:	−781.97	−628.77	−448.963	−343.00
Fitted Model:	−781.88	−620.734	−438.261	−317.78
Full Model:	−778.60	−614.037	−431.131	−302.59
Deviance:	11.83	23.80	37.30	97.88
Deviance/*df*	0.11	0.23	0.36	0.95
Pseudo R^{2}[c]	55.85%	49.76%	29.25%	21.85%
Pearson residual Moran test[b]: I	0.123	0.142	0.056	−0.003
sd[I][+]	0.061	0.059	0.064	0.06
prob	0.031	0.013	0.13	0.59

[a] The null model is the model fitted with just the offset and the country dummies; the fitted model is the model with only statistically significant covariates (5% level); the full model is the model with all the available covariates included whether statistically significant or not. The deviance equals −2 times the difference between the log likelihood for the fitted model and the log likelihood achievable by an exact fit (in which fitted values equal the data). Values of the deviance statistic divided by the degrees of freedom, if greater than 1, indicate overdispersion.

[+] The Moran coefficient is tested for significance using 999 randomizations to obtain the sampling distribution for the statistic under the null hypothesis of no spatial autocorrelation. Each run creates a different reference distribution under the null hypothesis. The standard deviation (sd) records the standard deviation for a typical run as does the reported probability of obtaining the observed Moran score under the null hypothesis.

[c] Pseudo R^2 obtained by correlating the observed offence rate with the predicted offence rate. Note it excludes the contribution of the offset variable.

here. There is no statistically significant spatial autocorrelation in the residuals. A map of the Pearson residuals is shown in Fig. 4(i).

Per capita area rates for robbery are highest in areas with higher divorce rates and higher population densities and, in Estonia, with lower levels of voter turnout. The significance of the population density variable is indicative of higher rates in urban areas which may be linked to there being a greater number of opportunities in urban areas (Sampson 1983). The significance of the divorce rate may signal an absence of formal social control, lower levels of social capital linked to family disruption and impoverishment of family conditions (Corcoran and Chaudry 1997, Sampson 1986). The association between low voter turnout and higher robbery rates may lend further support to the role of social capital. Again the combination of all these circumstances in any area will result in the highest rates of robbery (Tallinn, Tartu and Ida Viru in Estonia, Riga and Jelgava cities in Latvia and Siauliai and Klaipeda cities in Lithuania). As in the case of drug offences, this model too has low explanatory power but there is no statistically significant residual spatial autocorrelation. Figure 4(ii) shows a map of the Pearson residuals. Note that in both the case of drugs offences and robbery there is no evidence of the change variables being statistically significant.

Theft rates and car related theft rates were also modelled using the negative binomial. The model for thefts has the largest goodness of fit measure but it should be noted that the model has no explanatory power for Lithuania since none of the statistically significant variables vary within Lithuania. Moreover Latvia is only distinguished from the other two countries by having a lower estimated constant coefficient (β_0=−0.501–4.342=−4.843). The model provides little or no insight into the variation in theft rates across the three Baltic states. In addition the model's residuals are spatially autocorrelated at the 3% significance level. The model for car related thefts is not acceptable since model residuals are spatially autocorrelated at nearly the 1% level. We shall defer any further discussion of these results until we have considered an alternative modelling strategy.

The counts and rates for both thefts and car related thefts are larger than for the other two offences. A negative binomial model is defined by two parameters: $0<p<1$ and $r>0$. As r increases the negative binomial distribution loses its right skewness becoming more symmetric as it converges towards the normal distribution. The larger counts for these two offences means that the lower bound of 0 (and no administrative area had 0 counts for either of these offences) is less of a critical factor in model choice. Also, because the counts are large an increase or decrease induces a more continuous shift in the rate in keeping with the normal assumption. The relatively large areas used for this study also means that the problem of heteroskedasticity, whilst it needs to be monitored, is less likely to be a problem. Finally, the problem of residual spatial autocorrelation is less of an issue because there are normal models that can incorporate models for spatial autocorrelation.

Therefore a second phase of modelling was followed based on log (base e) transformed standardised ratios for both thefts and car related thefts. Standardised ratios, like rates, are calculated where areas differ in size (absolute values would tend to overemphasise large areal units) or where it is necessary to allow for differences in population characteristics between areas (Haining 2003). However standardised ratios are easier to compare than rates because they have a natural reference point which also assists in their inter-

Fig. 4 Quartile maps of the residuals from the final regression models: (i) Drug related offences; (ii) robbery; (iii) thefts; (iv) car related thefts. (i) and (ii) show Pearson residuals from the negative binomial model; (iii) shows OLS residuals and (iv) shows residuals (e_i) from the spatial error model defined in (2) and (3). (Light shading: First quartile; darkest shading: Fourth quartile. (v) identifies all the areas which are in the top quartile for three out of the four offences or four out of the four offences

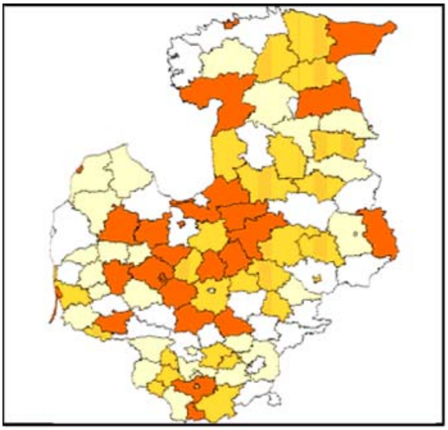
pretation. For other examples of standardised offence ratios, see Ceccato et al. (2002), Ceccato and Haining (2004). The standardised offence ratio (SOR) for region i is:

$$SOR_i = \frac{O_i}{E_i} x100$$

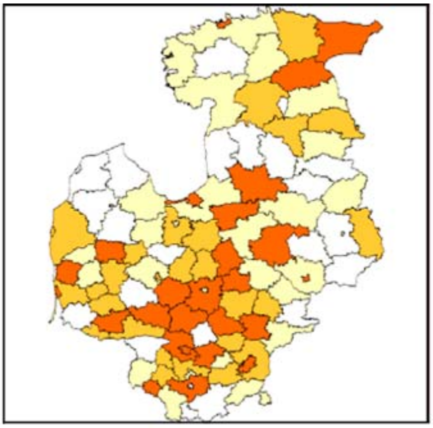
O_i is the observed number of cases of a specified offence and E_i is the expected number of cases of that offence. In this analysis, an average offence rate was obtained by dividing the total number of cases of the offence (all three countries) by the total population at risk (all three countries). For each area i, this average rate (θ) is multiplied by the size of the population at risk in area i to yield E_i. E_i represents the number of cases of the offence that would be expected in i if the offence occurred in proportion to the population at risk. The calculation of E_i implies no place-specific effects. An SOR_i greater than 100 means that there are more offences in i than would be expected if the offences occurred purely at random across the at-risk population and this may be indicative of some place-specific factors inflating crime rates in i. Similarly if SOR_i is less than 100 then there are fewer offences than expected and again there may be place-specific factors that account for this. For a fuller interpretation of these statistics their sampling variation needs to be allowed for (see for example Haining 2003:194–9). This method of calculating standardised ratios means that they are the offence rate for each administrative area divided by the average offence rate for the three countries. The average offence rate (per person at risk) for theft is 0.01568 and for car related thefts is 0.00454. Figure 5 illustrates an example of standardised ratios for thefts for 1993 and 2000. In dark grey, are the regions that had observed values higher than expected in that year (i.e. SORs greater than 100).

The distribution of standardised offence ratios for both offences are right skewed with evidence of some extreme values. Various transformations were tested but the log transformation was selected as producing a more nearly normal distribution also drawing extreme values closer to the overall distribution thus reducing the risk of outliers in the regression analyses. Although it is the errors that need to be normal rather than the dependent variable, normalizing the dependent variable often helps with this statistical assumption. The normal regression analyses were implemented using GeoDa 0.9.5–1 (Anselin 2003) since the software has regression modelling capabilities with a range of diagnostics relevant to spatial modelling that are not available in standard statistical packages.

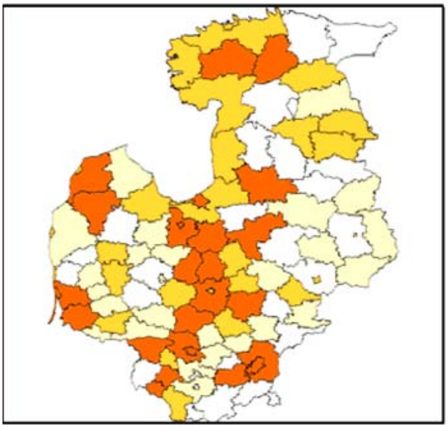
We first fitted the normal regression model assuming independent normal errors by ordinary least squares (OLS). Diagnostic checks included a test for multicollinearity and three for model residuals: the Jarque–Bera test for normality, the Breusch–Pagan test for homoskedasticity and the Moran test for residual spatial autocorrelation. The Moran statistic was computed using the OLS residuals and employing the same weights matrix discussed above. If the OLS residuals were found to be spatially autocorrelated, we fitted by maximum likelihood a normal regression model



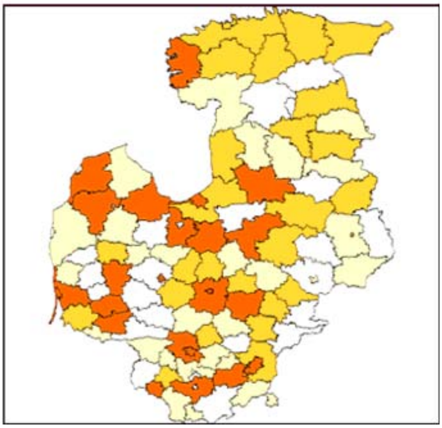
(i)



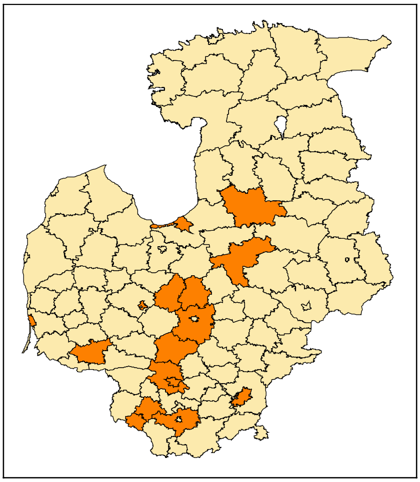
(ii)



(iii)



(iv)



(v)

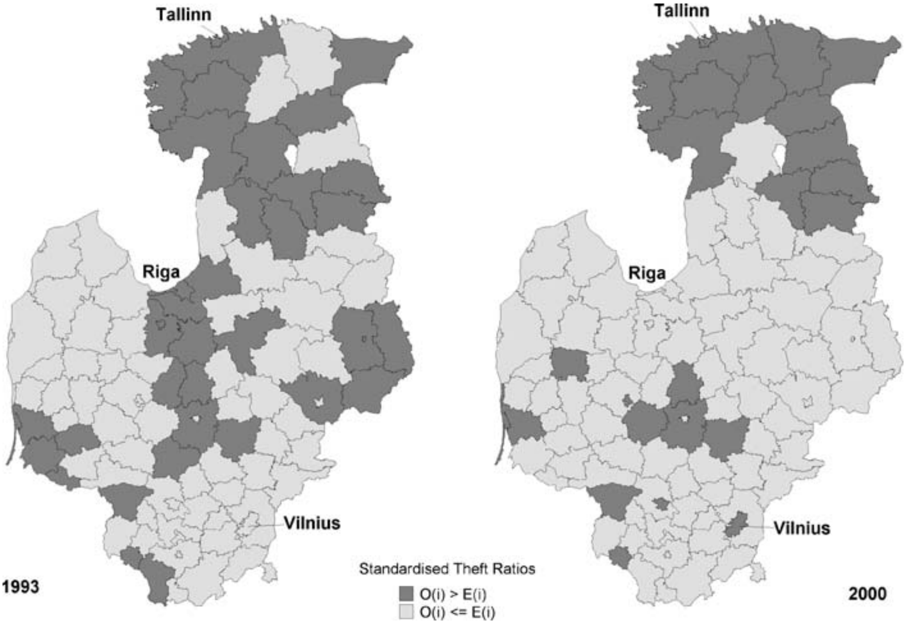


Fig. 5 Standardised theft ratios for Estonia, Latvia and Lithuania

with first order simultaneous spatial autoregressive errors, with spatial parameter ρ (see for example Haining 2003, p.313). This model is defined as follows (for i=1,…,n):

$$Ln[SOR_i] = \beta_0 + \beta_{0,1}D_{1,i} + \beta_{0,2}D_{2,i} + \sum_{k=1}^{K}\beta_k X_{k,i} + \sum_{k=1}^{K}\beta_{k,1}D_{1,i}X_{k,i} + \sum_{k=1}^{K}\beta_{k,2}D_{2,i}X_{k,i} + u_i \quad (2)$$

$$u_i = \rho \sum_{j \in N(i)} w_{i,j}u_j + e_i \quad (3)$$

where e_i is an independent normal random variable with mean 0 and variance σ^2. The set $\{w_{i,j}\}$ defines the set of row standardized weights as discussed above (with $N(i)$ denoting the set of neighbours of area i) as a consequence of which the spatial parameter ρ<1. The independent errors model fitted by OLS model, is a special case of (2) obtained by setting ρ=0. Results of model fitting for both offences are given in Table 3.

The OLS model for theft provides an acceptable model with no outliers or influential cases. The Jarque–Bera test retains the null hypothesis of normality of the residuals (p=0.345); the Breusch–Pagan test retains the null hypothesis of residual homoskedasticity (p=0.139) and the Moran I test retains the null hypothesis of no spatial autocorrelation (p=0.133). Figure 4(iii) shows a map of the OLS residuals. The multicollinearity condition value of 9, is well below the critical value, 20, indicating there is no problem. The R^2 adjusted for the number of fitted parameters is just under 70%.

Area rates for thefts are higher where divorce rates are higher and in the case of Estonia, where GDP per capita is higher and rates of natural population increase lower. Latvia has significantly lower rates than Estonia or Lithuania when controlling for the independent variables (β_0=3.7546–0.6015). This reflects the evidence in the table of descriptive statistics but may be a real difference or a recording difference. The social change variable is significant. Areas with higher rates of social change (in practice, areas with the highest annual rates of increase in divorce from the early 1990s to 2000) have lower theft rates in 2000. It is not clear how to reconcile these apparently conflicting results[9]. Variation in social change across the 107 areas is small so the power of our test is limited. The evidence of these model findings suggests that short term effects dominate. Divorce rates may be acting as a surrogate for an absence of formal social control whilst the GDP variable may be indicating the presence of suitable targets both variables consistent with a routine activities explanation for offence patterns. But as noted before, divorce rates may be associated with family breakdown and increasing levels of social disorganization (Sampson 1985, 1986).

The residuals for the OLS model for car-related thefts are spatially autocorrelated. Against all the other diagnostic checks the model is acceptable and there were no outliers or influential cases. So, the model defined by (2) was fitted and the spatial parameter ρ was statistically significant (p=0.004). The positive value, ρ=0.339, is consistent with having uncovered positive spatial autocorrelation in the OLS residuals. A Moran test of the residuals from this model (see $\{e_i\}$ in (3)) produced a probability of the null hypothesis of no spatial autocorrelation of 0.54 showing that the spatial error model had captured this element of variation.

The model results for car-related thefts are similar to those found for theft. Rates are highest in areas with high levels of GDP per capita (at the 7% significance level) and in areas with high divorce rates (In Estonia, Harju, Tallinn and Tartu; in Latvia, Riga and Jelgava cities and in Lithuania, Vilnius, Klaipeda, Kaunas but also Panevezys cities). The social change variable is statistically significant but with the same sign as found in the case of thefts. Only Latvia has a positive sign for its social change variable (4.6998–2.9471=1.7527)[10]. Latvia has other significant variables: higher car related thefts are found in areas with higher natural population increase and in areas of higher population density. Estonia has other significant factors with higher rates associated with lower levels of infant mortality, often urban areas. As with the offence of theft, short-term effects seem to dominate, and results suggest the importance of opportunity (higher levels of GDP per capita, lower levels of infant mortality as indicative of a higher standard of living and higher levels of population density) and social disorganization (higher divorce rates). Latvia offers a particularly marked example of the relationship of these factors to car related thefts together with a statistically significant social change factor.

[9] However this may not be a real change effect. The measure of social change is simply a difference in divorce rates at two points in time divided by the number of years to give a per annum rate of change. Disaggregating the change variable and combining parameter estimates with the divorce rate variable yields a measure that shows offence rates increasing with *past* divorce rates.

[10] The same comment applies as for thefts (see footnote 9). However, following the same disaggregation, Latvia's car related theft rate shows a strong association with the divorce rate in 2000.

Table 3 Results from fitting a normal linear model to the log transformed standardised offence ratios for theft and car related offences

Independent variables	Theft	Car related thefts
Medium term dynamics		
Social change: β	−1.7717	−2.9471
se[β]	0.3633	0.5393
prob	0.0000	0.0000
Social change: β		4.6998
[Latvia] se[β]		1.0464
prob		0.0000
Short term dynamics		
Divorce rate: β	0.2237	0.3611
se[β]	0.0375	0.0536
prob	0.0000	0.0000
GDP: β		7.90e-5
se[β]		4.37e-5
prob		0.071
GDP [Estonia]: β	0.0002	0.0003
se[β]	0.0000	8.92e-5
prob	0.0000	0.0000
Infant death rate: β		−0.0793
[Estonia] se[β]		0.0240
prob		0.0009
Natural increase: β	−0.3763	0.4621
in population se[β]	0.1580	0.1589
[Estonia| Latvia]^ prob	0.0191	0.0036
Other variables		
Population: β		0.0003
Density se[β]		0.0001
[Latvia] prob		0.0009
Latvia: β	−0.6015	
[Dummy] se[β]	0.0796	
prob	0.0000	
Constant: β	3.7546	2.8531
se[β]	0.1106	0.2061
prob	0.0000	0.0000
Spatial error model		
Parameter: ρ		0.339
se[ρ]		0.118
prob		0.004
Adjusted R^2	68.2%	66.8%
Multicollinearity condition	9.0	12.5+
Jarque–Bera test: prob	0.345	0.466+
Breusch–Pagan test: prob	0.139	0.999
Moran I test: prob	0.133	0.540

^ Theft: Estonia; Car related thefts: Latvia.

+ For the offence of car thefts, these diagnostics were obtained from OLS fit without the spatial error model. The Moran test on the OLS residuals gave a p-value of 0.006 indicating there was spatial autocorrelation in those residuals.

Acquisitive crimes concentrate in urban areas in the Baltic countries. As in many urban areas of the Western world, cities experience more thefts because of convergence in time and space of both more targets (stocks of goods) and motivated offenders than are found in rural areas. With the advance of a market economy, it is in urban areas where patterns of consumption often provide more opportunities for acquisitive crimes. Large cities often have larger socio-economic disparities and attract more individuals who consider crime as a way of acquiring goods. Moreover, acquisitive crimes tend to be more frequently reported in urban areas since individuals are geographically closer to police stations than they are in the countryside.

Figure 4 shows the regression residuals from the models discussed previously. All capital cities (exception Riga for drug related offences) show positive residuals, which means that offences are underpredicted by the regression models in these areas (darkest shading). Positive residuals are also found in more remote regions, particularly in Lithuania and Latvia for all types of acquisitive crimes (e.g., Panevezys and Aizkraukle). Negative residuals (areas where offences are over-estimated by the regression model) do not follow any apparent spatial pattern but for all types of crimes they tend to be found in the less densely populated areas of Latvia (e.g., Kraslava and Rezekne) and Lithuania (e.g., Svencionys, Ignalina, Varena and Salcininkai) and in Estonia (Viljandi).

Figure 4(v) identifies all the areas which are in the top quartile for three out of the four offences or four out of the four offences (orange). Fourteen out of 17 of these areas belong to Lithuania (Panevezys, Kedainiai, Kaunas, Kaunas city, Vilnius city, Alytus, Kalvarija, Taurage, Klaipeda, Pakruojis, Pasvalys), the rest are in Latvia (Jurmala city, Riga city, Aizkraukle, Marijampole, Siauliai, Daugavpils). Particularly for Lithuania, crimes are clustered in space, often following the transport corridors or city district municipalities.

Conclusions

This paper has reported findings on the changes in crime levels in the transition countries of Estonia, Latvia and Lithuania between 1993 and 2000. It has also reported associations between crime rates in 2000 and social, economic, and demographic variables. Variables that measure the *levels* of these variables in 2000 and variables that measure *changes* in social, economic and welfare variables in the late 1990s have been included in the regression modelling so that within the limitations of the available data and the methodology of aggregate spatial statistical modelling the paper has reported on the extent to which offence rates in 2000 are related to short term and medium term dynamics. The latter group of variables have been taken as indicative of the shifts taking place within transition societies. Based on the evidence gathered in this study, we draw the following conclusions:

1. According to police statistics, the total number of acquisitive crimes increased in the Baltic countries between 1993 and 2000 but there were differences across crime types (some even decreasing) and different Baltic states showed different change patterns over time. Although they follow similar trends as found in Western European countries (particularly for robbery and drug related offences) some acquisitive crimes had lower rates than Western European countries (e.g., thefts), which may be partially explained by different reporting practices.
2. The index of social change was found to be significant for two out of the four crimes but even in these cases (thefts and car-related thefts) the evidence of a real change

effect was questioned. Surprisingly, neither the economic change nor the welfare change variables were significant in any of the models. The post-independence Baltic states enjoyed quite high rates of growth (higher than Russia where Kim and Pridemore (2005) carried out their study) but this growth varied spatially. Relative economic disadvantage within a single state might be expected to act as a trigger for certain types of acquisitive crime. One possible implication of these findings is that the effects of transition processes on offence rates, to the extent that they were present at all, have now worked their way through. We take the view that, data permitting, future research should try to use other indicators of social change rather than the ones used in this analysis. However contrary to the model specification in Kim and Pridemore (2005), we take the view that model specification requires the inclusion of both *change* and *level* variables in order to capture both the slower (medium term) and faster (short term) social dynamics that affect crime rates. This is also necessary statistically in order to control for the effects of short term dynamics in evaluating the relationship of offence rates to medium term dynamics.

3. Acquisitive crime is a phenomenon typical of urban or densely populated regions in the Baltic countries. Economically leading regions are often large urban areas or capital cities. Here both the positive and negative sides of the new market economy are experienced: an increase in investment creates new jobs and increases the supply of goods (targets) but also exacerbates income disparities through wage differentials and selective unemployment (increasing the pool of motivated offenders). It is likely that a more subtle measure than population density is needed to distinguish between urbanised and non-urbanised regions. We do not think that adding in an urban dummy variable would be sufficiently sensitive. This needs further attention because there may be an urban dynamic towards offending that is much stronger than that occurring in non-urbanised areas with urban areas acting as magnets drawing in motivated offenders to commit offences from other areas. Moreover, the on-going suburbanisation process of the three Baltic capital cities (Tammaru 2005, Marana 2006, Daunora and Juskevicius 2006) are affecting people's mobility within these urban agglomerations and, should consequently, have an impact on crime patterns.
4. The size of the geographical units used in this analysis make it difficult to speculate in any detail on the role of social and behavioural processes to an understanding of offence rate variation. However there is some evidence that it is variables associated with social disorganization theory and a lack of social cohesion (e.g. the divorce level, voter turnout rates and the proportion of the population who are non-native) that play a leading role and this accords with findings in other Western societies. These findings illustrate the importance of assessing the impact of structural *change* on crime – a topic that is of considerable importance for those dealing with the short and medium term formulation of social/welfare policies in the enlarged EU.

The analysis shares limitations with other analyses of crime in transition countries. First, although the quality and reliability of crime data have improved since the beginning of the 1990s, still very little is documented about how changes have affected crime recording in these countries. Second, because of a lack of data, the indices of change had to be calculated for different periods of time using the variables that were available. As census and other social and economic data improve over time it should be possible to build better empirical models and carry out tests of hypotheses with greater power. Third, the spatial units are large and likely to be rather socially and economically heterogeneous so although crime rates calculated for such areas should be quite robust at this scale they will reflect a diversity of underlying societal conditions within each area. It is also important to note that regions are not sealed units and economic disadvantage in one region may trigger higher rates of offending and offence rates in other areas as motivated offenders travel or migrate to find suitable targets. Linking offence outcomes in an area to the characteristics of that area is for this reason problematic, the more so when the important drivers bringing about societal change are operating, as here, at a national level so that the uncertainties and instabilities created by that change are spatially extensive and endemic.

It is important to employ appropriate regression modelling techniques in order to test hypotheses. The arguments for using the negative binomial probability distribution to model counts, especially for offences where counts are small and rates low, are persuasive. However modelling data collected for contiguous geographical areas raises special issues – and the smaller the geographical unit the more likely this is to be a problem. If residual spatial autocorrelation is ignored this undermines statistical inference. It is essential therefore to test for the presence of spatial autocorrelation and the methodology employed here is one route. However if residual autocorrelation is detected the analyst needs to consider how to address the problem (see for example Haining et al. 2008, submitted). Here we have implemented one approach which is to fit a normal model after log transforming the dependent (rate) variable. This will not always be a good way to proceed.

Regression models only establish statistical associations and such models fitted to area data suffer from the effects of the modifiable areal unit problem (see for example Haining 2003 p.150–1). Parameter estimates and tests of hypothesis are dependent on the scale and partitioning of the study area in terms of which the data have been collected – in terms of which the underlying reality has been captured. These areal units are, in criminological and socio-economic terms, arbitrary. Any attempt to infer causal mechanisms linking a dependent variable to the statistically significant independent variables is potentially highly misleading. One way to deal with this issue in the future (see for example, Jackson et al. 2008, submitted) is to set up a modelling framework based on the integration of longitudinal individual data (such as data on offence, victim, and offender) and aggregate level data (e.g., indicators of region level structural conditions). A nested modelling framework might also be a better way to handle the effects of data collected across three countries. There is some evidence in the results presented here that introducing country dummies has not proved entirely satisfactory in separating out the two scales of spatial variation in the data. This is a modelling issue and one that we expect to return to in a future study.

The search for more adequate independent variables should be part of future studies aiming to test the effect of medium term structural dynamics on crime over time. The inclusion of variables that function as good indicators of social institutions as moderators of poor socio-economic conditions on crime is an example. In addition, future studies should test the importance of differences in regions' functionality (e.g. if they contain capital cities, holiday resorts or industrial towns) and locational factors since we expect that they will affect human interactions and, as a consequence, crime rates. An important area of study that has not been covered by this article is the effect of organized crime on expressive crimes in the Baltic countries. It would be useful to investigate whether there are links between international/regional organized crime and crimes that take place within national territories. However, despite these limitations, results from this study enhance current research on relationships between processes of change and crime by providing empirical evidence from three Baltic countries in the 1990s. They form interesting case studies not only in relation to western countries but also in relation to other post socialist states undergoing similar structural changes.

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Appendix

Table 4 Characteristics of the dataset

Type of data	Description	Year	Source
Offences	Type[a]		
	Theft (domestic burglary, theft of cars, theft from cars, pick pocketing)	1993–2000	Estonian Police Board
	Car related thefts (theft of and from a motor vehicle)		Latvia's Ministry of Interior
	Robbery		
	Drug related offences		Lithuania's Ministry of Interior
Level variables	Divorce rate per 1000 inhabitants	Estonia: 2000; Latvia: 2000; Lithuania: 2001	Statistics Estonia
Demographic, socioeconomic and welfare	Deaths under 1 year old per 1,000 live births	Estonia: 2000; Latvia: 2000; Lithuania: 2001	
	Hospital beds per 1,000 inhabitants	Estonia: 2000; Latvia: 2000; Lithuania: 2001	
	GDP per capita in Euros	Estonia: 2000 (NUTs 3), Latvia: 2000, Lithuania: 2000	Central Statistical Bureau of Latvia
	Foreign direct investment per capita in Euros	Estonia: 2000; Latvia: 2001; Lithuania: 2000	
	Natural increase	Estonia: 1999; Latvia: 2000; Lithuania: 2001	Statistics Lithuania
	Net migration	Estonia: 1999; Latvia: 2002; Lithuania[b]: 2000	
	Male population aged 15–29	Estonia: 2000, Latvia: 2000, Lithuania 2001	
	Non-native population	Estonia: 2000;Latvia: 2000; Lithuania: 2000	
	Unemployment rate	Estonia: 2000, Latvia: 2000, Lithuania: 2000	
	Voter turnout in parliament elections	Estonia: 2000; Latvia: 2000; Lithuania: 2000	

Table 4 (continued)

Type of data	Description	Year	Source
Change variables	Index of welfare change	Deaths under 1 year old per 1,000 live births and Hospital beds per 1,000 inhabitants: Estonia: 1990 and 2000; Latvia: 1990 and 2000; Lithuania: 1994 and 2001.	Statistics Estonia
Indices of change[c]	Index of economic change	Foreign direct investment per capita in Euros, unemployment rate: Estonia: Estimated and 2000; Latvia: 1995 and 2001; Lithuania: 1996 and 2000.	Central Statistical Bureau of Latvia
	Index of social change	Divorce rate per 1000 inhabitants: Estonia: 1992 and 2000; Latvia: 1990 and 2000; Lithuania: 1994 and 2001.	Statistics Lithuania
Other variables	Dummy for border regions	Estonia: 2000, Latvia: 2000, Lithuania: 2005	
	Population density		
Geographical units	107 units for the Baltic region (Estonia: 15, excluding Hiiumaa, Saare and other small islands, Latvia: 33 and Lithuania: 59.	Seamless Administrative Boundaries of Europe (SABE): 2005	Eurogeographics

[a] **Crime Definitions: Total criminal offences** – This category should include all offences defined as criminal by any law. This should include minor offences such as breaches of public order, vandalism and traffic offences. According to ESCCJ (2003), only in Latvia are public order offences included in total criminal offences. **Theft** – Theft means depriving a person/organisation of property without force with the intent to keep it. Where possible, the figures include: burglary, theft of motor vehicles, theft of other items, and theft of small value. Burglary – Burglary is gaining access to a closed part of a building or other premises by use of force with the intent to steal goods. Where possible, the figures include theft from a factory, shop or office, from a military establishment or by using false keys. They should exclude however theft from a car. According to ESCCJ (2003), Estonia and Latvia include theft of cars in burglary counts. **Theft of a motor vehicle** – Theft of a motor vehicle should where possible include joyriding but exclude theft of motor boats handling/receiving stolen vehicles. According to ESCCJ (2003), Estonia excludes joyriding whilst theft of motorboats is included in these statistics in Lithuania. **Theft from a motor vehicle** – Theft of objects contained in a motor vehicle, either by the use of force (burglary) or not. **Robbery** – Robbery means stealing from a person with force or threat of force. Where possible, the figures include: muggings (bag-snatching), theft with violence, but exclude: pick pocketing, extortion, blackmail. According to ESCCJ (2003), Lithuania excludes muggings. **Drug related offences** – Drug offences should include possession, cultivation, production, sale, supplying, transportation, importation, exportation and financing of drug operations. Drug trafficking – Drug trafficking should include where possible drug offences (as defined under g) which are not in connection with personal use.

[b] Some of the voting districts were adjusted to accommodate the spatial units used in this study (SABE, Eurogeographics, 2005). Attributes were joined or split when necessary.

[c] **Indices of change** were calculated using the differences between the start and end dates for a variable divided by the number years (as rates per year).

Table 5 Descriptive statistics at the administrative area level

Variables	Estonia		Latvia		Lithuania	
	Mean	SD	Mean	SD	Mean	SD
Population at risk	85,754	96,774	72,042	126,746	58,534	84,918
Offence rates per 10,000						
Theft	204.49	88.17	78.86	26.57	125.66	60.32
Car Thefts	32.68	30.08	18.47	12.87	34.15	30.56
Robbery	1.64	1.89	4.57	4.45	7.14	6.65
Drugs related	5.68	11.42	1.55	2.75	1.59	2.21
Covariates						
Short term dynamics						
Divorce rate	2.51	0.60	2.21	0.69	2.82	0.81
Infant deaths	9.57	3.92	11.12	5.27	8.92	5.72
Hospital beds	64.22	21.37	73.40	49.21	71.16	32.12
GDP per capita	3094.4	296.3	1850.0	1305.0	3535.0	779.0
FDI per capita	295.2	222.0	1090.0	1776.0	222.9	466.7
Natural pop^{n}. inc.	−0.46	0.16	−0.49	0.26	−0.37	0.27
Net migration	−0.04	0.18	−0.08	0.64	0.00	0.43
Males 15–29	10.15	1.02	11.01	1.66	10.26	0.90
Non-native	20.2	21.3	31.6	18.9	11.3	20.0
Unemployment	13.47	3.66	10.81	5.37	14.67	5.18
Voter turnout	56.52	1.75	70.55	4.41	45.23	3.40
Medium term dynamics						
Economic change	−0.18	0.14	−0.74	1.01	0.01	0.90
Social change	0.01	0.08	−0.12	0.05	0.02	0.09
Welfare change	−0.80	0.55	−1.08	1.72	−0.96	1.18
Other variables						
Population density	208.0	668.0	333.0	688.0	280.0	691.6
No. of admin. areas	14	33	60			
No. of border areas	11		24		28	

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