Urban Studies
46(8) 1611–1638, July 2009

Crime in a City in Transition: The Case of Tallinn, Estonia

Vânia Ceccato

[Paper first received, October 2006; in final form, June 2008]

Abstract

The objective of this article is to characterise the criminogenic conditions of an eastern European city experiencing the transition from a planned to a market-oriented economy. Tallinn, the capital of Estonia, has been chosen as the case study. The article first describes the various levels of a set of expressive and acquisitive offences in Tallinn and then assesses whether patterns of crime in Tallinn are caused by underlying processes similar to the ones indicated in the Western literature of urban criminology. The study identifies variables that most significantly contribute to the variation of crime ratios using regression models, GIS and spatial statistical techniques. Findings suggest that, although there is no dramatic difference between the geography of crimes in Tallinn and those found in western European and North American cities, some of the explanatory variables function in ways which would not be predicted by Western literature.

1. Introduction

Political and social transformations have had a profound effect on cities experiencing the transition from a planned to a market economy (Åberg and Peterson, 1997; Kliimask, 1997; Sýkora, 1999; Sailer-Fliege, 1999; Kährik, 2002; Kulu, 2003; Ruoppila and Kährik, 2003; Weclawowicz, 2005; Häussermann and Kapphan, 2005; Tosics, 2005; Musil, 2005a, 2005b; Pichler-Milanović, 2005; Hamilton *et al.*, 2005, Rudolph and Brade, 2005; Nuissl and Rink, 2005).[1] The shift from a planned to a market economy has engendered 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. Moreover, a growing economy with rising levels of consumption provides more opportunities for crime (Iwaskiw, 1996; Ceccato and Haining, 2008). At the same time, evidence at a regional level shows that anomic feelings, produced by an increase in economic disparity, generate more violence and disorder where population

Vânia Ceccato is in the Department of Urban Planning and Environment, Royal Institute of Technology, Drottning Kristinas väg 30, Stockholm, 10044, Sweden. E-mail: vania@infra.kth.se.

0042-0980 Print/1360-063X Online

DOI: 10.1177/0042098009105501

decay and signs of deprivation are evident (Ceccato, 2008). There is a need to obtain empirical evidence about the composition and geography of crime in urban areas and how this relates to such global and state-level transformations and also to the cities' intraurban characteristics (Bottoms and Wiles, 2002). This is particularly important for transitional cities because of the unkown effect of recent rapid transformations on urban crime. The current literature on crime patterns in former socialist cities suggests that structural and social processes similar to those in western cities have had an impact on where crime takes place (Bartnicki, 1986; Dangshat, 1987; Smith, 1989). However, such evidence is out of date and not detailed enough to enable comparisions with patterns found in western European cities. The objective of this article is to make a contribution to this knowledge base by characterising the criminogenic conditions for a set of expressive and acquisitive crimes committed in a city in transition using Tallinn, Estonia, as an example.

This article makes two contributions to the study of spatial variations in urban crime. First, it characterises the geography of expressive and acquisitive crimes in Tallinn. Using maps of standardised offence ratios, it identifies areas that run a relatively high risk for a certain offence, taking into account the distribution of that offence in Tallinn as a whole and in each zone. Expressive crimes can be defined as criminal acts that serve to vent rage, anger or frustration, such as assault, homicide or vandalism; acquisitive crimes refer to offences where the perpetrator derives material gain. In this paper, acquisitive crime refers to thefts, robbery and drug-related crimes. Drug offences, which have drastically increased in the Baltic countries as a result of both an actual increase as well as the capacity of the police to tackle drug crime (European Council, 2003; Ahven, 2004), can be regarded as acquisitive offences since they are highly correlated with property crimes (for example, Holloway *et al.*, 2004). Although there is no clear-cut divide between what is termed an expressive or an acquisitive crime, the selection of offences in this study was based on existent crime codes and definitions as well as descriptions of the crime event provided by the police authorities.

Secondly, the study assesses whether patterns of crime in a city in transition follow similar processes to the ones indicated in the Western literature of urban criminology. The study identifies variables that most significantly contribute to the variation of crime ratios using regression models, GIS and spatial statistical techniques. The selection of the tested variables was based on two major complementary theoretical approaches in the urban criminology of western European and North American cities: social disorganisation theory (for example, Shaw and McKay, 1942; Kornhauser, 1978; Bursik and Grasmick, 1993) and routine activity theory (for example, Cohen and Felson, 1979; Sherman *et al.*, 1989; Osgood *et al.*, 1996). Whilst social disorganisation theory is based on the idea that structural disadvantage breeds crime (studies based on social disorganisation theory often use area-based indicators of poverty, ethnicity and residential stability and typically deal with expressive crimes), the routine activity approach deals with the dynamics of the crime event. Crimes, according to routine activity theory, depend on the convergence in space and time of motivated offenders, suitable targets and an absence of responsible guardians. The routine activity approach has been particularly useful to explain the geography of acquisitive crimes.

Tallinn has been chosen as a case study for several reasons. Tallinn is a typical city in transition. It has experienced the shift from a planned to a market economy, but also the impact of Estonia's entry in the European Community in 2004. The effects of the transition are said to have created new and increasing inequalities (Kährik, 2006), making more visible the previously latent socio-spatial segregation in Tallinn, which is common in many other post-socialist cities (Kliimask, 1997; Sýkora, 1999; Sailer-Fliege, 1999; Kulu, 2003; Weclawowicz, 2005; Häussermann and Kapphan, 2005; Tosics, 2005; Musil, 2005a, 2005b; Pichler-Milanović, 2005; Åberg, 2005; for review, see Åberg and Peterson, 1997; Hamilton *et al.*, 2005). So far, very little evidence exists on how Tallinn's past and its current structure may generate criminogenic conditions that may lead to crime. By using the existent literature on crime patterns from North American and western European cities as a basis, this analysis endeavours to discover support for the generalisibility of spatial theories of crime from the western to eastern European cities.

Homicide rates did not surpass 5 per 100 000 inhabitants in most large western European cities between 2001 and 2005 (Table 1). In contrast, the rate was above 10 per 100 000 in 2005 in Tallinn.[2] Tallinn also has higher prevalence rates for acquisitive crimes, such as burglary, than the average for capital cities in western Europe (4.8 versus 2.9 per cent) according to the 2000 International Crime Victim Survey (del Frate and van Kesteren, 2004). Since empirical evidence in the field of urban crime patterns is largely based on case studies from western Europe or the US (for example, Shaw and McKay, 1942; Reppetto, 1974; Sherman *et al.*, 1989; Wikström, 1991; Ceccato *et al.*, 2002; Coupe and Blake, 2006), Tallinn constitutes an interesting case study to be investigated from eastern Europe. Specifically, Tallinn has historically had an important role among capital cities of the former communist bloc (Kährik, 2006), and also among centres of the urban hierarchy of Nordic countries and eastern Europe. Tallinn acts as one of the main transport gateways between continental Europe and northern Eurasia (Hanell and Neubauer, 2005, p. 15; Hamilton *et al.*, 2005), which has had an important effect on the region's economy, including on illegal activities driven by organised crime (for example, Junninen and Aromaa, 2000).

This particular study has been made possible by better-quality crime data becoming available for Estonia at the intraurban level. This study was based on a detailed and extensive geo-referenced crime database for Tallinn which was only made accessible in

Table 1. Crime rates for selected cities (offences recorded by the police per 100 000 inhabitants)

	Homicide	*Assault*	*Robbery*	*Theft*	*Vandalism*	*Drugs*
Tallinn city	12	268	240	4410	226[a]	155
Vilnius city	9	368	174	1871	1991	—
Stockholm city	4	1300[b]	269	3928	2808	1126
London	2	663[b]	460	3815	1271	225
Berlin	4	347	233	3238	1682	369
New York	7	361	300	1542	—	—
Detroit	39	1264	627	2733	—	—

[a] Underreported, often classified as misdemeanours.
[b] Includes simple and aggravated assault.
Sources: Tallinn: Estonian Police Board, 2005; Vilnius: Ministry of Interior, 2001; Stockholm: The Swedish National Council for Crime Prevention, 2005; London: London Metropolitan Police, 2001; Germany: Federal Criminal Police Office, 2005; New York: Federal Bureau of Investigation, 2003; Detroit: US FBI, Crime in the US, in: *Statistical Abstract of the United States* (2003).

2002 by the police authorities. This is of great importance since data on space–time variations in criminal events in post-socialist cities were, until recently, rare. Detailed crime data were either unavailable for research or of poor quality. The analysis of such a large database was made feasible by the use of geographical information system (GIS) technology and spatial statistical techniques.

The paper is structured as follows. Section 2 contains a brief review of literature in the field of crime patterns and how they relate to urban structure. In section 3, Tallinn is framed as a case study. The empirical analysis starts in section 4 with issues regarding data quality, followed by a discussion on how standardised offence ratios have been calculated. It is also in this section that the areas at high risk of crime in Tallinn are discussed. In section 5, the focus is on the results of the models. Patterns of offences in Tallinn are then compared with patterns found in western European and North American cities, as outlined in section 2. Finally, section 6 summarises the main findings and considers directions for future work.

2. Patterns of Intraurban Crime

Only a small number of studies have reported the nature of urban crime in socialist cities. Warsaw is one of the few cities that has internationally published records on its intraurban crime structure during the socialist era. In the 1970s and throughout the 1980s, criminal activity in Warsaw was concentrated either in north-western housing complexes with many social problems; or in areas of the city centre, which were particularly vulnerable to theft after its redevelopment (Bartnicki, 1986, p. 240; French and Hamilton, 1979). The problematic areas of the north suffered from deprivation and poor building design, providing very few chances for effective security (Bartnicki, 1986, pp. 240–241). Dangshat (1987, p. 51) also refers to the existence of 'social dropouts' (young offenders, social allowance receivers, alcoholics and violence) in certain parts of the Polish city.

Smith, after examining social differentiation in several socialist cities, suggests that crime in such urban areas tends to happen in

> old and deteriorating neighbourhoods, usually in central areas, and some of the new lower-status residential complexes in the outer districts (Smith, 1989, p. 30).

Offenders seemed to be overrepresented by single rural migrants who were no longer "subject to the traditional controls of family and community". Thus, even after independence, crime in these cities was regarded as a social pathology associated with specific parts of the urban fabric only. Crime was said to be generated by particular land uses (Bartnicki, 1986), as well as conditions equivalent to 'social disorganisation', which seemed to some extent be similar to the conditions found in Western cities (with the exception of the widely accepted opinion that socialist cities were generally characterised by a low level of segregation). After independence, many eastern European capital cities have experienced a rise in drug-related offences and other illegal activities related to organised crime, such as human trafficking and prostitution (for example, Juska *et al.*, 2004; Aral *et al.*, 2006) that might have an effect on local criminogenic conditions for all sorts of crime. So far, the literature suggests that structural and social processes similar to those in Western cities have an impact on the geography of crime in post-socialist cities, but such evidence lacks a link to processes at the intraurban level.

Next will be outlined some of the main features of studies dealing with urban crime in Europe and North America for both expressive and acquisitive offences. The section is divided into two parts; the first reviews a selection of studies on expressive crimes (homicide, assault and vandalism) and the second focuses on the geography of acquisitive offences (thefts, robbery and drug-related crimes). This review functions as a background to what will be used to compare with Tallinn's results in section 5.2.

2.1 Expressive Crimes

The analysis of expressive crimes is heavily directed by social disorganisation theory. Demographic composition is known to be a good predictor of the level of violence, especially in deprived areas. The highest homicide rates are registered for young males (Yunes and Zubarew, 1999; Fox and Piquero, 2003). More importantly, social disorganisation theory links many forms of crime with the presence of weak informal social controls (Shaw and McKay, 1942; Kornhauser, 1978; Wilson, 1987; Craglia *et al.*, 2001, 2005). High homicide rates are a sign of severe social disorder. Some researchers argue that the effect of poverty on generating violence is not as important as the impact of 'relative deprivation' (Burton *et al.*, 1994). Thus, the fact that a group is relatively deprived in relation to others provides the conditions for conflict and violence. Cultural differences in values, norms and beliefs held by members of groups or sub-groups are seen as important in explaining variation in rates of violence, particularly in the US (Messner and Rosenfeld, 1999). Situational factors, such as differences in land use, also play an important role in the distribution of violent crime in a city (Bromley and Nelson, 2002; Kubrin and Weitzer, 2003).

For assault, Andresen (2006) noticed that high violent crime rates in Vancouver were positively related to high unemployment rates and population change, but also associated with high-income areas with an ethnically heterogeneous population. Zhu *et al.* (2004) found a clear association between alcohol outlet density and violence, including assault, after analysis of data from two American cities (Austin and San Antonio, Texas). In the UK, assault is worst in the evenings and at weekends, and is positively related to deprivation (Downing *et al.*, 2003).

Although considered a less serious crime, vandalism is an indicator of other underlying social problems. Reviewing research on vandalism in the UK, Evans (1992) found correlations between housing ownership, income and vandalism. The highest rates of vandalism reported by the Islington Crime Survey were experienced by the highest income earners. In other studies cited by Evans, the areas of highest risk were those with high levels of owner-occupied housing, irrespective of whether they were inner-city areas or not. In Sweden, Wikström (1991) showed that vandalism within the inner city was associated with the location of places of public entertainment. For the outer city, a significant proportion of the spatial variation in vandalism was related to social problems or disorganisation. Also in Sweden, Torstensson (1994) showed that shops in areas of Stockholm with a low degree of social stability were more exposed to various kinds of offences (including vandalism) than shops in other areas. Ceccato and Haining (2005) showed that the spatial variation in vandalism in the Swedish city of Malmö was significantly related to social disorganisation risk factors as well as land use factors, and that the physical presence of local leisure facilities produced higher vandalism rates.

2.2 Acquisitive Crimes

The routine activity approach has been particularly useful to explain the geography of acquisitive crimes. For car-related theft, Evans (1992) reported empirical findings from British cities that indicated a relationship between car-related theft and low socioeconomic status. Residents of inner cities, flats and maisonettes and council tenants are most at risk of car crime (theft of and from cars).

This finding from British cities corresponds with findings elsewhere. Car thefts were concentrated in the downtown area spreading out to commercial and residential areas in a study by Andresen (2006) in Vancouver, Canada. Unemployment rates as well as the number of people in an area throughout the day (ambient population) are important predictors of automotive theft. In Stockholm, Wikström (1991) found area variation in car-related theft to be strongly related to area variation in public violence and vandalism. The highest rates were found in the city centre of Stockholm or nearby areas. In suburban areas, car-related theft tended to be highest in areas with social problems, predominantly in areas with flats in multistorey houses. In Malmö, Ceccato and Haining (2004) found that car-related thefts were concentrated in areas close to train and bus stations, but also in areas with a large young male population, high housing mobility, a low share of foreign populations and many local leisure facilities.

Robbery, although regarded as a violent offence, is beyond a doubt an acquisitive crime. Smith *et al.* (2000) showed that both disorganisation and routine activity variables impact on street robbery in a medium-sized US city. Distance from the city centre is a key variable to the conceptualisation of social disorganisation theory and indicates that street robberies are more likely to occur in the context of mixed land use and where family structures are weaker. Their findings also provide evidence that street robbery involves diffusion processes; street robberies on one block will influence street robberies on nearby blocks. Sherman *et al.* (1989) suggested that robberies in Minneapolis, US, took place in clusters within 0.3 km of each other and the vast majority were located on seven main avenues. Also in the US, Duffala (1976) showed that robberies also tend to concentrate near convenience stores close to vacant land or away from other commercial areas. In the UK, Barker *et al.* (1993) used data from London to identify that inner-city areas were particularly prone to robbery. Smith (2003) found that a large number of personal robberies in the UK occurred in open public spaces, primarily streets, but also footpaths, alleyways, subways and parks. Almost 40 per cent of personal robberies occurred either in or around locations other than a street, such as commercial premises or while the victim was using some form of transport—that is, in city-centre areas and transport nodes. Ceccato and Haining (2004) suggested that, in the Swedish city of Malmö, the closer an area is to a shopping area, a university campus or harbour areas, the higher the relative risk of robbery.

Vehicle crime, burglary, shoplifting, robbery and handling of stolen goods are highly correlated with drug-related crimes in the UK (Holloway *et al.*, 2004); therefore they could be expected to have similar geography. It is no surprise that neighbourhoods with the greatest number of known drug users are located within some of the most socio-economically deprived areas (Haw, 1985). However, drug-selling points are not always where consumers live. They are often in places of easy access, such as close to transport nodes and regional commercial centres. In Malmö, areas with a high relative risk of narcotic-related offences are the ones close to bus and train stations, and the university campus (Ceccato and Haining, 2004). Forsyth *et al.* (1992) studied drug users in Glasgow, Scotland, and showed that users tend to travel to obtain cheaper drugs and that drug problems in poor areas are often exaggerated by outsiders.

Taken together, the existing literature on spatial crime patterns suggests that structural and social processes have an impact on where crime happens. This study follows the recent Western research on crime and hypothesises that both social disorganisation theory and routine activity theory can contribute to the explanation of spatial patterns of crime in Tallinn. Hence, this study will test the following hypotheses

(1) Expressive crime is expected to be more frequent in the most socially disorganised neighbourhoods—in this case, areas with a high proportion of long-term socially excluded groups, as predicted by social disorganisation theory.
(2) Assuming principles of routine activity theory, it is likely that the most acquisitive crime will occur in central areas of the city, followed by regional commercial centres. Areas which concentrate both transport nodes and public entertainment (such as pubs and clubs) should be a particular target for crimes, particularly acquisitive ones. Crime will be the result of the interplay between the supply of targets (goods/victims) and demand (motivated offenders), regulated by potential guardians in places where human activities converge.
(3) As for the comparative dimension, it is assumed that the empirical findings regarding Tallinn's geographical patterns do not fundamentally differ from the ones found in Western capitalist cities.

The next section will present how the factors and processes discussed thus far are expected to impact on Tallinn. It will outline aspects which make the city distinct from other parts of the world including, in some respects, other large cities in eastern Europe.

3. Framing Tallinn as a Case Study

As much as 45 per cent of all registered criminal offences in Estonia are concentrated in Tallinn. Thefts, particularly car-related thefts, robberies and drug-related crimes are more frequent in Tallinn than in the rest of the country.[3] The 2000 International Crime Victim Survey confirms this concentrated pattern of victimisation. Most offences in Tallinn are seasonal (for similar results, see Hakko, 2000 and Rotton and Cohn, 2004).[4]

Some of Tallinn's characteristics are thought to be important in criminogenic terms and these will be considered now. Some are key to defining Tallinn's levels of crime in relation to other places in Estonia and elsewhere, whilst others regulate its intraurban variations in offences. Although it has a relatively small population compared with other Baltic capital cities (388 958 inhabitants in January 2007), Tallinn is a gateway not only to Nordic countries but also between the East and West. Baltic and Nordic regions, because of their geographical proximity and well-developed economic structures (in banking and transport), play an important role as receptors and transit territories for international organised crime, especially those operating from the east (Ulrich, 1994; Galeotti, 1995; Junninen and Aromaa, 2000). Moreover, improving air and sea transport links with western Europe in the past decade have made Tallinn easily accessible to tourists, who have greatly increased in numbers since independence (Estonian Tourist Board, 2005). During the summer season, a ferry or hovercraft departs just about every hour from Tallinn to Helsinki and back. Estonia has a regular boat connection with Sweden and, in the summer, also with Germany. Tourists are often unfamiliar with the risks they face in an unknown environment and become easy targets for crime. Since the number of tourists is quite large in comparison with Tallinn's population, especially in summer, tourists become an attractive target for thieves.

In countries like Estonia, where the transition from a planned to a market economy is still taking place, socioeconomic polarisation is not yet as tangible as in western European cities. One of the reasons is that post-socialist cities have been less socioeconomically segregated and less polarised than capitalist cities (Dangschat, 1987; for a review, see Smith, 1996). Traditionally, the socioeconomic status of the population in Tallinn was higher in the suburban detached housing areas and particularly in the highly valued high-rise housing estates, and lower in the working-class district of northern Tallinn. Some of these spatial differences also have an ethnic dimension. Of all EU member-states' capital cities, Tallinn has the largest number of non-EU nationals: 28 per cent of its population are not EU citizens (Eurostat, 2006). Planned immigration from other Soviet republics during the period of Soviet control brought in large numbers of non-Estonians, mostly Russians. Many of these immigrants and their offspring do not automatically qualify for Estonian citizenship. As suggested by Aasland and Flotten (2001, p. 1024) this is already "a form of exclusion which may lead to a *feeling* of social exclusion as well". There has been evidence of ethnic conflicts and discrimination in Estonia (Vetik, 1993; Swimelar, 2001). Since independence, efforts have been made to re-integrate ethnic minorities, but challenges still remain. Differences in the lifestyles and long term socioeconomic marginalisation of certain ethnic groups may cause differences in propensity to offend between ethnic Estonians and other ethnic groups (see, for instance, Lehti, 2001, for the case of ethnic Russians). Non-Estonians are over-represented among drug abusers and are more prone to commit property crimes (NIHD, 2005). Non-Estonians (particularly Russians) are overrepresented in flats (for example, in Lasnamäe and northern Tallinn) while Estonians are concentrated in detached housing (for example, in Pirita and Nõmme). In some of these areas with flats, the unemployment rate reached more than 30 per cent of the labour force in 2005, while Tallinn's average

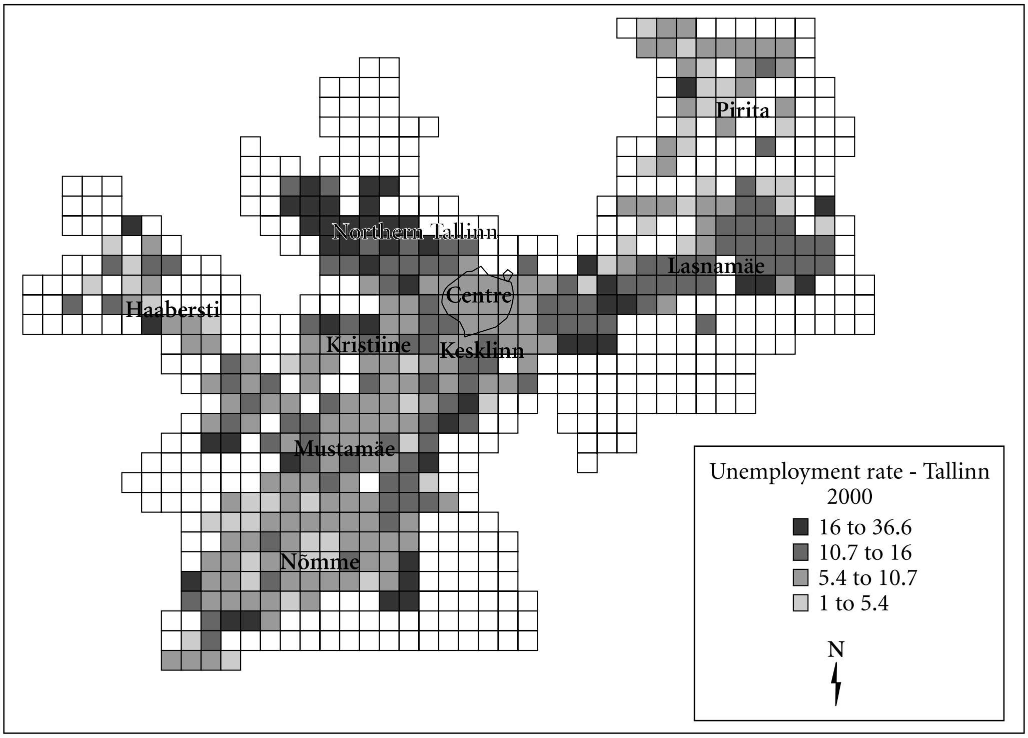

Figure 1. Unemployment rates in Tallinn, 2000

Scale: Grid squares are 500 × 500 metres.
Note: Areas in white are excluded, having fewer than 20 inhabitants.
Source: Statistics Estonia.

was 8.2 per cent (Figure 1). Kährik (2002) suggests that, although the pattern of ethnic differentiation has remained largely the same since socialist times, poor non-Estonians started to move from the housing estates to the lower-quality flats whilst Estonians became even more concentrated in areas with detached houses.

As in other post-socialist cities (Rudolph and Brade, 2005; Nuissl and Rink, 2005), new large commercial and business services have been established in Tallinn since the early 1990s. In addition to becoming a seaport and capital city, Tallinn has in recent years developed an information technology sector (most foreign direct investment is located in the Tallinn area). Banks, governmental and private institutions, and other businesses, attract a large part of the labour force and transients who populate the streets in the most central areas during day time. Regional centres and new shopping areas on the outskirts also attract visitors. Parking lots and transport nodes close to these commercial areas are particularly vulnerable to acquisitive crimes.

4. Empirical Analysis

4.1 The Dataset and Issues of Data Quality and Availability

Data on offences were obtained from the Central Criminal Police in Tallinn. Police records for a selected group of offences (see Appendix) between June 2004 and May 2005 were used in this analysis. This one-year georeferenced database contains data for type of offence, crime code, when the crime occurred (date and time-interval), crime location by street name, house or building number and the respective *x–y* co-ordinates. Although 13 per cent of these selected offences (which compose nearly 95 per cent of all registered offences in Tallinn) failed to be mapped during the geocoding process, this matching rate is slightly higher than what is considered reliable by the literature (for example, Ratcliffe, 2004). The matching rate for mapping crimes is dependent on crime type. All homicide cases were geocoded but often crimes that took place at specific addresses (such as burglaries, here included under theft), have a higher hit rate for matching than other offence categories. Robbery, drug-related crimes and vandalism contributed the most to the overall mismatch total.

In Estonia, as in other countries, official crime statistics reflect not only changes in penal code but also police practices and population attitude towards police and other public authorities.[5] Registration of drug-trafficking cases was low before the second half of the 1990s due to a lack of specialised police units to deal with these crimes. Thus, the significant increase in the number of drug offences since the late 1990s reflects both an increased police capacity to tackle drug crime and an increase in actual drug-related crimes (European Council, 2003; Ahven, 2004). As in other central-eastern European countries, crime reporting rates have been lower in Estonia than in western European countries. According to the 2000 International Crime Victim Survey, on average, half of the incidents reported took place in western European countries and only one-third in central-eastern Europe. In Tallinn, this difference in reporting might be associated with the population's dissatisfaction with the police—62 per cent; the highest rate amongst 25 surveyed cities (del Frate and van Kesteren, 2004).

A digital grid map covering the city of Tallinn (see Figure A1, Appendix) was obtained from Estonia's Statistical Office and used as a basis for the spatial modelling analysis. The digital boundaries of the grids are composed of 500 by 500 metre squares (TM-Baltic 93 projection). These grid cells were used for analysis instead of irregularly shaped administrative area polygons. Although grid cells facilitate multiple coverage analysis for single cells, their arbitrary boundaries may pass through neighbourhoods, splitting ‘natural’ boundaries, which is likely to affect spatial modelling (Worboys and Duckham, 2004). Data on population demography and socio-economic status were also obtained from the Estonia Statistical Office and matched to the individual grids (excluding grids with less than 20 inhabitants). The total population of these cells varied from a minimum of 21 to a maximum 6057, with an average of 1066 and standard deviation of 1307. From the offices of Tallinn city council, *x–y* co-co-ordinates of pubs and clubs, bus/tram/train stops and transport lines were obtained and later aggregated by grid cell (see Appendix).

4.2 Areas of Relative High Risk of Offences in Tallinn

Cities differ internally in their criminogenic levels and patterns of crime. In order to identify areas in Tallinn at relatively high risk of selected groups of offences, the urban area was broken down into 374 square grid cells. From each grid square, the number of a selected offence was counted and a standardised offence ratio (SOR) was calculated using data from June 2004 to May 2005. The SOR for grid cell *i* is given by the ratio of the observed number of a certain offence O_i by its expected number of that offence in Tallinn E_i

$$\mathrm{SOR}(i) = (O_i / E_i \times 100$$

The expected number of an offence was obtained by dividing the total number of that offence in Tallinn by the total size of the resident population. An average offence rate was obtained by dividing the total number of cases of the offence (city) by the total population at risk (city). For each area *i*, this average rate (θ) was multiplied by the size of the population at risk in area *i* to yield E_i. Standardised ratios, like rates, are calculated where areas differ in size (absolute values would tend to overemphasise large area units) or where it is necessary to allow for differences in population characteristics between areas (Haining, 2003), such as in these grids. Standardised ratios are easier to compare than rates because they have a natural reference point to assist their interpretation. A SOR 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 that cell (on the advantages of using ratios instead of rates, see Haining, 2003; and for other examples, see Ceccato and Haining, 2004, 2005, 2008). Figure 2 shows examples of areas at a high relative risk of theft and robbery, identifying all areas where $O_i > E_i$ in relation to some key land use indicators.

Very few areas are at a high relative risk of homicides (there were 45 recorded cases between June 2004 and May 2005). Moran’s I-test (Boots and Getis, 1988) was used to test for spatial autocorrelation of SORs. Moran’s I is positive when nearby areas tend to be similar in attributes, negative when they tend to be more dissimilar than one might expect and approximately zero when attribute values are arranged randomly and independently in space. In order to calculate Moran’s I, a binary weight matrix based on shared common boundaries was used to represent the spatial arrangement of the city (Rook’s matrix is set to 1 if the pair of cells share a common edge and 0 otherwise, first-order criterion). For homicides, cells are often isolated (note that Moran’s I-test is not significant; see Table 2) and contain transport nodes within them (which can be indicative of robbery followed by death) and, at least for some of them, are located in areas with high unemployment rates. Three districts have concentrations of homicides: Lasnamäe (Mustakivi and Pae), Kesklinn (Torupilli) and northern Tallinn (see Appendix). Although areas at relatively

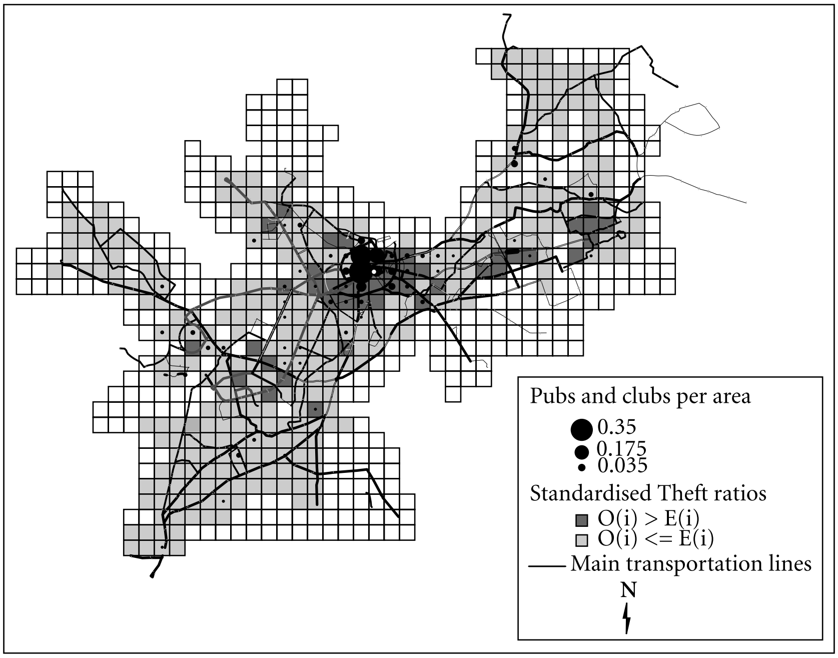

Figure 2. Areas with a relatively high risk ($O_i > E_i$) of thefts
Scale: Grid squares are 500 × 500 metres.
Note: Areas in white are excluded, having fewer than 20 inhabitants.

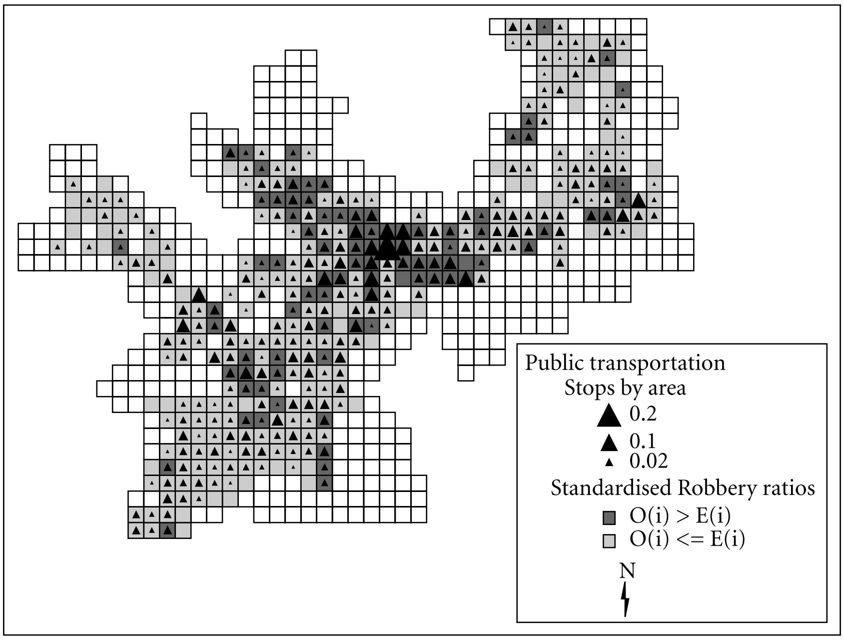

Figure 3. Areas with relatively high risk ($O_i > E_i$) of robbery-related offences
Scale: Grid squares are 500 × 500 metres.
Note: Areas in white are excluded, having fewer than 20 inhabitants.

high risk of assaults are spread all over Tallinn (no significant cluster was found; see Table 2), there are a few concentrations of assaults which have, without exception, the same geography as homicides. Central areas in Kesklinn show a relatively high risk for assaults but also peripheral areas, such as the areas surrounding shopping centres in Haabersti, Mustamäe, northern Tallinn and Lasnamäe. In terms of socioeconomic standards, these areas are quite heterogeneous; some are considered deprived, whilst others are more wealthy. The geography of vandalism is composed of a few distinct clusters (Moran's I is significant at 99 per cent); some are central (parts of Kesklinn), whilst others are peripheral and often close to areas with mixed land use, such as schools, hospitals, shopping centres and transport nodes (as in a few areas of Mustamäe, Kristiine, Lasnamäe and northern Tallinn; see Appendix).

With regard to acquisitive crimes, thefts are highly clustered in space in Tallinn (Table 2). Areas with a relatively high risk of theft are more often concentrated in the central areas of Tallinn than those at risk from other types of acquisitive crime (robbery and drug-related offences). There are, however, a few clusters of thefts in Lasnamäe and Mustamäe, which may result from contamination of the data on thefts by data on burglary, which often has a more dispersed pattern. The largest cluster of thefts is found in Kesklinn, where the CBD, old town, hotels and most pubs and clubs are located, followed by smaller hotspots at large transport nodes and in commercial areas (markets and shopping centres) in Lasnamäe and northern Tallinn (Figure 2). The pattern of areas at high risk of robberies is very similar to the one found for assault (but slightly more clustered) and more spread out than that of thefts, being drawn to commercial areas on the outskirts of the city (Figure 3). Drug-related crimes certainly follow the geography of drug selling-points, occurring near the city centre or close to bus, train and tram stations spread throughout the city (from Nõmme and Pirita to Lasnamäe and northern Tallinn) but with no statistical significant clusters (see Table 2).

Table 2. Moran's-I test for spatial autocorrelation (for first-order contiguity)

Standardised offence ratios	*Moran's I*	*Probability*
Homicide	–0.01	0.85
Assault	0.01	0.75
Vandalism	0.32	0.00
Thefts	0.14	0.00
Robbery	0.08	0.04
Drug-related offences	0.004	0.87

5. Modelling Expressive and Acquisitive Crimes

The results of modelling the geography of selected expressive and acquisitive crimes using demographic, socioeconomic and land use variables as covariates are presented in this section. The dependent variables used here are the standardised offence ratios (SORs) whilst the independent variables encompass some of the key correlates of neighbourhood crime rates previously outlined as suggested by the current literature (see Appendix). Two distinct dimensions are tested.

(1) *Social disorganisation risk factors*. These have long been associated with high crime rates, particularly of expressive crimes, in the western European and North American literature. Unemployment, ethnic background, education and housing quality and ownership were included in the model as measures of social disorganisation and deprivation in these grid cells after the size of the population of 12–25-year-old males was controlled for. High population density was also included in the model as a source of ecological strain producing conflicts

and violence (Roncek and Maier, 1991) but also as an indicator of places where the convergence of targets/victims and motivated offenders is more likely (Cohen and Felson, 1979; Wikström, 1991). Thus, the lower the population density of an area, the lower the number of crimes.

(2) *Routine activity variables*. Patterns of human activity, including crime, are influenced by land use. Thus, land use variables were included in the model in order to take situational effects into consideration. The locations of pubs and clubs and nodes of public transport (bus, train and trams) were included as these land use variables identify areas where the population converges. According to the theory of routine activity, this convergence may generate particular criminogenic conditions especially for acquisitive crimes.

The strategy for assessing the results of the models was as follows. First, it was determined which and how many covariates from each theoretical approach (routine activity or social disorganisation) emerge as significant in the regression models using a backwards regression approach. Secondly, an assessment was made of whether the signs of significant covariates, in relation to dependent variables, are the same as those found for western European and North American cities. For instance, thefts are often positively related to land use variables, while homicides are inversely related to low levels of deprivation.

The individual covariates were pre-selected before modelling. First, an analysis of correlation between all covariates identified variables that would potentially contribute with similar information to the models. Since the explanatory variables were not highly correlated (the highest was R = 0.7, between dwellings with no heating and dwellings with no hot water), all the chosen variables were kept. Initially, the linear regression model was fitted by ordinary least squares (OLS) in order to test the statistical significance of covariates in explaining the variation in expressive and acquisitive crime ratios. Since the values of the set of crime ratios show a highly skewed distribution, the raw standardised crime ratios were log transformed to produce more normal distributions. The regression analysis was implemented in GeoDa (Anselin, 2004). GeoDa provides several statistics measuring the fit of the model and includes diagnostic tests, such as tests for multicollinearity among independent variables and tests on model errors (normality, heteroscedasticity and spatial autocorrelation). In order to test for spatial autocorrelation in the residuals and incorporate a notion of 'neighbourhood' between grid cells (proximity of location), a binary weight matrix based on shared common boundaries was used to represent the spatial arrangement of the city (rook matrix, first-order criterion). With this matrix, a lagged variable can be incorporated into the model as an independent variable and be tested for a 'spill-over' effect. This is particularly important since offenders' behaviour is often motivated by local factors, but sometimes shows elements of a spatially contagious process, spilling over into nearby areas. Most of the models presented problems of heteroscedasticity of the residuals. For the problem of non-constant variance of the residuals, a common practice is to include a categorical variable (in this case: centre and periphery), in the ML–Ghet model—groupwise heteroscedasticity as suggested in Anselin (1992), which is available in SpaceStat 1.91.

5.1 Model Results

Table 3 summarises the significant coefficients of the models whilst the Appendix shows in detail the initial list of covariates input into the model using a backward approach.

Expressive crimes. For homicide, none of the covariates came out significant. Although homicide rates are relatively high in Tallinn in comparison with western European cities, homicides are in general rare events. Further, in the particular case of Tallinn, they do not show any link either with the spatial variation of land use or the socioeconomic variables used in this analysis.

Centrality and non-residential land use are associated with a higher risk of assault and vandalism. The model results confirmed this with the significance and expected sign of the following routine activity variables: proportion of transport nodes, such as bus, trains and trams stops; proportion of pubs and clubs; and population density. Both assault and vandalism are concentrated in the inner-city areas of Tallinn, following main roads, stations and local centres. These places are mostly constituted by either transport links (such as main streets) or transport nodes (such as train stations)—public places that lack 'capable guardians' despite being crowded areas (for similar results, see Brantingham and Brantingham, 1991). Apart from the inner city, mixed land use areas in densely occupied parts of northern Tallinn show a higher risk of assault and vandalism, which indicates that the pattern of these crime types tends to match the geography of the most socially disorganised neighbourhoods. Whilst foreign population is not significant, unemployment rate and house ownership are significant predictors with expected signs for assault and vandalism. The importance of the unemployment rate as a strong covariate in determining the variation of standardised assault rates has already been found by Andresen (2006). This may be indicative of a lack of social stability or a high level of social disorganisation (Shaw and McKay, 1942). The relationship between the proportion of young males and assault is not easily interpreted and seems to run counter to expectation; the same occurs for the occurrence of vandalism and proportion of dwellings with no heating (not connected to the public heating system).

As in the assault model, the explanatory variables for vandalism do not suffer from multicollinearity or spatial autocorrelation on residuals. However, both models show that the errors are not normal even after the log transformation of the dependent variable. Despite the improvements, residuals still do not show a constant variance after using ML–GHET model for assault ratios, which implies that the regression estimates are not efficient. Conclusions should therefore be drawn carefully in the case of assault.

Acquisitive crimes. The spatial variation in robbery ratios is very similar to that of expressive crimes. After controlling for the problem of heteroscedasticity (ML–Ghet model), the robbery model accounts for 34 per cent of the variation in the ratios. Robbery is concentrated in areas of high population density, public transport nodes and more pubs and bars per area. Robbery is concentrated in inner-city areas but, as with assault and vandalism, shows a few clusters in mixed land use areas, corresponding to public transport stations and local centres. Indicators of social disorganisation are also relevant to explain the variation in standardised robbery ratios. Robbery tends also to take place where the unemployment rate is high, people do not own their houses and few dwellings have hot water facilities. Similar results were previously found in Western literature by Sherman *et al.* (1989), Smith *et al.* (2000) and Ceccato and Haining (2004).

The model results suggest two contrasting components to the geography of theft. High relative risk of theft appear to occur both in the busier more central areas, where pubs and clubs and transport nodes are concentrated, and in areas with a low population density, in more peripheral areas. The level

Table 3. Regression results for expressive and acquisitive crimes ratios in Tallinn ($N = 374$)

Offences	*Model*	*R^2 (LIK)*	*Significant variables*	*Diagnostic tests*
Expressive				
Homicide	—	—	—	—
Assault	OLS (log)	31.7(–808.4)	2.5 Constant 19.4Pubtransp*** 12.1Pubs&Clubs*** 112.2PopDens*** –0.05YoungMale** 0.13Unempl*** –0.02HouseOwn***	Multicol. cond number 15.2 Jarque–Bera 19.7, prob 0.00 Koenker–Basset 30.40, prob 0.00 Moran's I 0.58, prob. 0.56
	Error ML–Ghet model (log)	32.7 (–803.4)	3.0 Constant 21.1Pubtransp*** 10.5Pubs&Clubs*** 108.4PopDens*** –0.05YoungMale*** 0.01Unempl*** –0.02HouseOwn*** 0.008Lambda	Test in Groupwise (centre and elsewhere) heteroscedasticity Likelihood ratio 9.9, prob 0.01
Vandalism	OLS (log)	33.1 (–807.7)	1.95 Constant 33.2Pubtransp*** 18.8Pubs&Clubs** 93.9PopDens*** –0.01HouseOwn*** –0.002NoHeating***	Multicol. cond number 13.2 Jarque–Bera 76.6, prob 0.00 Koenker–Basset 6.9, prob 0.32 Moran's I 0.86, prob 0.39
Acquisitive				
Robbery	OLS (log)	34.9 (–806.9)	1.7 Constant 16.7Pubtransp*** 16.1Pubs&Clubs*** 138.8PopDens*** 0.07Unempl*** –0.02HouseOwn***	Multicol. cond number 11.7 Jarque–Bera 56.6, prob 0.00 Koenker–Basset 22.4, prob 0.00 Moran's I 1.1, prob 0.25
	Error ML–Ghet model (log)	33.7 (–801.7)	1.2 Constant 29.9Pubtransp*** 15.5Pubs&Clubs*** 160.9PopDens*** -0.02HouseOwn** 0.06Unempl** 0.01NoHotWat* 0.1Lambda*	Test in Groupwise (centre and elsewhere) heteroscedasticity Likelihood Ratio 2.59, prob 0.27
Thefts ($N = 354$)	OLS(log)	26.37 (–471.06)	4.74 Constant 12.68Pubtransp*** 7.86Pubs&Clubs** –83.98PopDens***	Multicol. cond number 2.8 Jarque–Bera 31.5, prob 0.00 Koenker–Basset 8.75, prob 0.04 Moran's 3.9, prob 0.00

(*Continued*)

(**Table 3** *Continued*)

Offences	*Model*	R^2 *(LIK)*	*Significant variables*	*Diagnostic tests*
	Spatial lag model[a]	28.52 (–463.05)	3.45 Constant 0.27W_Y*** 10.93Pubtransp*** 5.84Pubs&Clubs** –73.37PopDens***	Jarque–Bera 15.76, prob 0.00 Lagrange multiplier on spatial error dependence 2.69, prob 0.10
Drug related offences	OLS (log)	19.3 (–804.5)	0.28 Constant 19.4Pubtransp*** 8.1Pubs&Clubs* 146.9PopDens***	Multicol. cond number 2.7 Jarque–Bera 78.7, prob 0.00 Koenker–Basset 12.7, prob 0.01 Moran's I 3.9, prob 0.00
	Spatial lag model[a]	20.1 (–800.1)	0.20 Constant 0.14W_Y*** 18.9Pubtransp*** 123.3PopDens***	Breush-Pagan 31.7, prob 0.00 Lagrange multiplier on spatial error dependence 6.2, prob 0.01

[a] Spatial error models were also tested but showed poorer performance (see Anselin, 1992).
Notes: *** significant at the 1 per cent level; ** significant at the 5 per cent level; * significant at the 10 per cent level. *Y* = standardised offence ratios.

of explanation attained by the model is relatively poor (around 27 per cent) but this may in part be due to the dichotomous nature of the underlying pattern. Twenty areas located at the boundaries of the city had to be excluded from the model as outliers.[6] Autocorrelation of the residuals was present in the OLS results. In this case, a common practice is to fit either a lagged response model or a spatial error model to try to handle the problem of autocorrelation in the residuals (for more details, see Anselin, 1992). The lagged response model includes a lagged form of the response variable as one of the independent variables. This variable is calculated by taking the sum of the observed and expected counts in the adjacent areas and dividing the sum of the observed counts by the sum of the expected counts. The error model provided the means to deal with the presence of spatial autocorrelation in the regression model residuals without adding new variables into the model.[7] For completeness, both types of model were used and their results compared with the ones from the OLS model. Both models were run because they are similar in statistical terms and choosing between them may be a difficult task when faced with just the diagnostics from the OLS model (Ceccato and Haining, 2005). The spatial lag models produced better results when comparing the results from both models (for instance, the maximised likelihood of the spatial lag model was larger than that of the spatial error model). The much poorer performance of the error model is because it retains fewer significant predictors and spatially autocorrelated variation is assigned to the error component of the model. The results from the lagged response and OLS model are similar. The exception is that, in the OLS, model residuals are autocorrelated (a problem that is solved in the lagged response model). Heteroscedasticity is still a problem but to a lesser extent. Table 3 shows that the lagged independent variable emerged as significant, indicating that thefts in Tallinn may be showing a diffusion pattern.

Nearly one-third of the total theft took place in the central area of Tallinn, which encompasses about 5 per cent of the city's area. The significance of transport nodes and pubs and clubs indicates the importance of the city's main core in explaining theft ratios in that area. As expected, these areas bring people together, creating an opportunity for theft, with potential offenders and victims being there at the same place and time as previously suggested by Cohen and Felson (1979) and exemplified by numerous studies in Western literature. Transport lines (trains and roads), although not present in the model as covariates, show a clear match with high levels of theft in the most peripheral areas, such as Haabersti and Pirita.

Although the model explains about 20 per cent of the variation for drug crimes, the results reflect the location of potential drug selling-points, as suggested in Ceccato and Haining (2004) in the case of the Swedish city of Malmö. These are mostly central areas, with a high concentration of bus, train and tram stops, but also include the densely populated area of northern Tallinn. Although the spatial lag model performed slightly better than the OLS model, spatial autocorrelation of residuals still remains a problem.

Another dimension of these findings is that there is some evidence of a 'spill-over effect' for theft and drug crimes in Tallinn (W_Y variables are highly significant). It is common that criminogenic conditions spill over neighbourhood boundaries into an area that may vary in shape and size over time (Ceccato, 2005) reflecting, for instance, police practices (Deutsch and Epstein, 1998). This may also be an effect of the way the crime data were aggregated. Grid data split continuous urban environments into separated zones, so cells with high offence ratios are found often adjacent to other cells with high offence ratios. This indicates that certain areas appear to suffer high levels of theft or drug crimes not so much because of their internal characteristics but rather because of their geographical proximity to areas with actual high levels of these offences (Reppeto, 1974).

5.2 Tallinn's Geography of Crime: The Importance of Social Disorganisation and Routine Activity Theories

The results here suggest the existence of several overlapping dimensions which explain the spatial variation of crime ratios in Tallinn. Although both social disorganisation and land use variables are important for explaining the variation of all crime ratios in Tallinn (Table 3), they differ in the way they contribute to the models. Routine activity variables are by far the most important type of covariates in explaining the variation in standardised offence ratios when compared with social disorganisation variables. However, indicators of social disorganisation play a more important role in explaining the variation of standardised expressive crime ratios (such as assault) than acquisitive crimes (robbery is an exception).

Crimes, but specifically assault, robbery and vandalism, tend to be more concentrated in areas where social disorganisation indicators tend to dominate, as initially suggested in hypothesis (1). The unemployment rate was the most important covariate among the social disorganisation variables, emerging as significant in all three models. Most acquisitive crimes occur in central areas of the city, the next-most-common areas are regional commercial centres. Areas which have higher concentrations of both transport nodes and public entertainment such as pubs and clubs were also a particular target for acquisitive crimes. These findings are in accordance with the patterns proposed in hypotheses (1), (2) and (3). Based on the evidence gathered in this study, there is no dramatic difference between the geography of selected crimes in western European and North American cities and those found in Tallinn.

There are, however, a few exceptions. For assault, vandalism, robbery and theft, some of the covariates do not function as would be expected from findings in western European cities (mostly, the direction of the relationship is not as expected). One reason could be that Tallinn is a special case that cannot easily be framed by the traditional theories in urban criminology. This could be caused by the following factors. First, the 'lack' of a basic urban infrastructure is not always indicative of deprivation—for example, in the more affluent detached housing areas in Tallinn. Some of these dwellings might not be connected to the public system (on which the statistics are based), having traditional sewage collection or private heating systems, but are nevertheless highly valued in the housing market. In the past and following local traditions, Estonians often improved their living conditions by building their own family houses because of the difficulty in obtaining public rental housing (Ruoppila and Kährik, 2003, p. 54). More recently, improvements in housing conditions have been facilitated through loans (Feldman, 2000, pp. 5–7). During Soviet control, these traditional housing areas were 'left' for ethnic Estonians, while the guest workers from other parts of USSR were attracted to modern high-rise buildings in the periphery, often with basic infrastructure.[8] According to Ruoppila and Kährik (2003, p. 58), in general, flats constructed since the 1960s have all the basic facilities. Since independence, the situation has been reversed: traditional housing, including some old apartments in the most central parts of the city, have become highly valued in the market. Furthermore, in certain areas, old apartments have become gentrified, even when some of these basic urban infrastructures may be lacking or are old-fashioned (for example, houses in Nõmme are relatively old but highly prized). The once-modern peripheral high-rise buildings, with low or no maintenance since their construction, have become a place for those entering the housing market or who cannot afford a better standard of housing. This mismatching affects the way crime patterns are modelled and interpreted. Future studies should therefore test other covariates (such as income polarisation) at a more local level than the geographical units used in this study to reach a better understanding of the relationship between crime geography and underlying socioeconomic factors in cities in transition. For instance, there are even indications that social polarisation is taking place at the household level (for example, Kährik, 2002; Kulu, 2003).

Secondly, although having a large foreign population is related to social economic exclusion and crime in areas of Tallinn in the same way as in most western European cities at the aggregate level, this causal relationship may have a different dynamic in post-Soviet cities (in Tallinn, for instance, the variable indicating ethnic background was never a significant predictor of high-crime areas). Whilst in western European cities the large majority of the foreign population is ethnically heterogeneous and relatively newly arrived from non-European countries, in Tallinn the large majority of foreigners came from other Soviet republics during the period of Soviet control (these include mostly Russians, but also Ukrainians and White Russians). When comparing native Estonians and non-Estonians, Kährik (2006) shows, for example, that not many changes took place with regard to their place of residence during the 1990s. It could be expected that ethnic minorities in Tallinn have reached a certain degree of integration and are not therefore as vulnerable to the impact of social and economic exclusion as the foreign populations in western European cities. This might partially explain why the foreign population variable turned out to be not significant in the models despite the fact that it shows high bivariate correlation with high unemployment rates.

Another reason is that the socioeconomic conditions in the places where crimes occur do not necessarily represent the socioeconomic situation of the offenders, since they are mobile. This is possibly the greatest limitation of analyses such as this one since individuals move around. Methods that link crime to characteristics of the resident population have had a limited explanatory power. In order to have a more precise picture of the underlying factors affecting crime geography, it would be interesting to know where individuals are at certain times and whether their social and environmental contexts affect their decision to commit crime.

Finally, and less interestingly, some of the covariates do not always function in the expected way simply because the models are mis-specified. It is likely that some variables are 'surrogates' for the behaviour of missing covariates. In other cases, the way some of the variables were included in the model was not satisfactory. The incorporation of new variables into these regression models is essential if explanatory performance is to be improved; a few suggestions are discussed in the next section. Moreover, the distribution of standardised offence ratios became closer to normal after log tranformation, but skewness was still problematic in almost all models. Although this should not invalidate the results, conclusions from these models should be made cautiously.

6. Final Considerations

Nearly half of all recorded criminal offences in Estonia are concentrated in Tallinn. Theft, particularly car-related theft, robberies and drug-related crime is more frequent in Tallinn than in the rest of the country. This one-year database shows that most offences in Tallinn are seasonal, following patterns similar to those found in the literature.

Tallinn also differs internally in its criminogenic conditions and levels of crime. This article inspected the risk maps for different crime types to identify areas with high relative risks of crime and compared them with patterns of the different covariates. The second stage employed spatial regression modelling in order to identify covariates that would describe the variation in relative risk. Despite the remaining unsolved modelling problems, findings provided evidence that there is no dramatic difference between the geography of selected crimes in western European and North American cities compared with that of Tallinn. Principles from both social disorganisation theory and routine activity theory are important in explaining the variation of crime ratios in Tallinn. However, these two sets of covariates differ in how they contribute to the models to explain the variation of crime ratios. Thus, the results presented here provide support for the generalisibility of spatial theories of crime from the West to transitional cities in eastern Europe.

An interesting finding is that robbery, here regarded as an acquisitive crime, showed a geography that was more similar to expressive crimes than to acquisitive ones. Also, theft and drug-related crimes clearly show a diffused pattern, suggesting that the underlying factors behind their spatial distribution act beyond the area's boundaries.

This article makes a contribution to the way crime data (until recently unavailable in Tallinn at co-ordinate level) can be aggregated in geographically detailed grid cells and further analysed using GIS. Spatial regression models were tested by incorporating the notion of neighbourhood and spatial diffusion. However, the analysis shares limitations with other cross-sectional analyses using aggregated data concerning crime and its covariates. In order to approach the question of the mechanisms underlying the relationship between area characteristics and crime, it would be beneficial to include individual-level data in the analysis. Individual data about offence, victim and offender should be integrated, so that all three components can be viewed in relation to their social and environment contexts, perhaps dynamically over time (see, for example, Ceccato and Wikström, 2006). In the case of Tallinn, little is known about the mobility of offenders—for example, whether or not they travel long distances to commit an offence or prefer to act locally. Another limitation is that the analysis is based on a one-year database which might be considered too narrow a time-period for drawing final conclusions on Tallinn's criminogenic conditions. Since in many post-socialist cities evidence suggests that spatial differentiation is still under way, future studies should focus on comparisons of cities' criminogenic conditions over time. For future research, one of the main challenges is to elucidate the processes through which socio-economic variables interact and influence levels of crimes in different neighbourhoods. The issue of high-crime areas as a path-dependency phenomenon could be explored using long-term data series. Another area that has not been focused on in this article is that of the daily temporal variation of crime, which it remains important to study. It would be useful to know if there is any difference in the geography of these crimes between day-time and night-time, for instance. City centres and regional commercial areas, in particular, would be more vulnerable to shifts in population, affecting the geography of crime hotpots—information that is crucial for local police forces in defining crime prevention measures. Despite these shortcomings, it is important to report the findings from Tallinn as a transition city; such findings, until now, have been non-existent in the literature. The results from this study can enhance current research and understanding about relationships between crime and intraurban differentiation by providing empirical evidence from an eastern European city.

Notes

1. By transition, is meant

    > a particularly significant stage of societal development in which more external and/or internal difficulties hinder the reproduction of the social and economic environment that forms the basis of society. New economic and socio-economic conditions emerge to become generally dominant in due course. Whether rapidly or slowly, violently or peacefully, these new conditions determine how the new system of society will look like (Enyedi, 1998, p. 9).

2. However, any comparision of crime rates should be made cautiously since they reflect not only actual criminality but also differences in penal code between countries, a population's willingness to report crime and changes in policy practices.
3. See Ahven (2004) for a complete analysis of the regional levels of crime in Estonia.
4. The differences in levels of crimes by season were tested using one-way Anova with a post-doc Scheffe test for a 1-year data sample and were significant at the 1 per cent level level.
5. See Ceccato and Haining (2008) for an extensive discussion of changes in penal codes in the Baltic countries.
6. The remaining models were also checked for the effect of these boundary areas as outliers.
7. The spatial error model is a regression model in which the usual assumption of independent and identically distributed normal errors (mean zero, variance sigma squared) is replaced by the assumption that the errors are multivariate, normal and follow a simultaneous spatial autoregressive model with a single spatial parameter that has to be estimated as part of the process of fitting the regression model (including estimating regression parameters) (Haining, 2003).
8. At the time, the authorities claimed to be treating all people equally according to their needs, while maximising the use of existing housing

stock and ensuring stock for all. The reality showed that the most valued public housing tended to be occupied by the political élite and other especially favoured groups, in which ethnicity would play a role (Kährik, 2002; Kulu, 2003; Ruoppila and Kährik, 2003).

Acknowledgements

The support of The Bank of Sweden Tercentenary Foundation (Riksbankens Jubileumsfond, grant J2004–0142:1) is gratefully acknowledged by the author. Thanks to colleagues Marti Reinola (Tallinn municipality), Kalvi Abel (Central Criminal Police) and Aira Veelmaa (Statistics Estonia) for providing data for the analysis. Thanks also Andri Ahven (Ministry of Justice, Estonia) and Robert Haining (University of Cambridge) for their long term support to this research project.

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Appendix

Table A1. Characteristics of the dataset

Type of data	*Description*	*Year*	*Source*
Offences[a]	Homicide Assault Robbery Theft Vandalism Drug-related offences	June 2004 to May 2005	Estonian Police Board Crime Analysis Division
Demographic and socio-economic indicators	*Proportion of*: Male population aged 12–25 years old (*YoungMale*) Foreigner population Population with university degree or higher Unemployed population (*Unempl*) House owners (*HouseOwn*) Dwellings with no sewage Dwellings with no hot water (*NoHotWat*) Dwellings with no flush toilet (NoFlushToi) Dwellings with no heating (Noheating) Population density (*PopDens*)	2000	Statistics Estonia
Land use indicators	*Proportion of*: Public transport stops (bus, trolleys and trams) per area (*PubTransp*) Pubs and bars per area (*Pubs&Clubs*)	2006	City of Tallinn
Maps	The digital boundaries (areas) of the grids (500 metres × 500 metres) with the numerical identifiers of the grids (covering the city of Tallinn), TM–Baltic 93 projection, $N = 374$ areas, excluding areas with less than 20 inhabitants (for Theft, $N = 354$)	2005	Statistics Estonia

[a] *Crime Definitions*: *Homicide*—intentional homicide means intentional killing of a person. Where possible, the figures include: assault leading to death, euthanasia, infanticide. According to European Council (2003), Estonia excludes assault leading to death and cases of euthanasia. *Assault*—assault means inflicting bodily injury on another person with intent. *Robbery*—robbery means stealing from a person with force or threat of force. *Theft*—theft means depriving a person/organisation of property without force with the intent to keep it. Where possible, 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 European Council (2003), Estonia includes theft of cars in burglary counts. *Domestic burglary*—domestic burglary is gaining access to private premises by use of force with the intent to steal goods. Figures on domestic burglary should include theft from an attic or from a basement as well as theft from a secondary residence. This should exclude theft from

(*Continued*)

(**Table A1** *Continued*)

a factory, shop or office, from a military establishment as well as from a detached garage, barn or stable, or from a fenced meadow/compound. 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. Estonia excludes joyriding. *Theft from a motor vehicle*—theft of objects contained in a motor vehicle, either by the use of force (burglary) or not. *Pick pocketing*—theft against a person but without directly hurting or threatening the victim. *Vandalism*—vandalism is a criminal offence involving damage to or defacing of property belonging to another person or the public. It can also be defined as a 'wilful or malicious destruction, injury, disfigurement, or defacement of any public or private property, real or personal, without the consent of the owner or persons having custody or control'. This should include damage to public and private property. *Drug related offences*—drug offences should include possession, cultivation, production, sale, supplying, transport, import, export and financing of drug operations. *Drug trafficking*—drug trafficking should include where possible drug offences which are not in connection with personal use.

Table A2. Descriptive statistics (N = 374)

Variables	*Description*	*Mean*	*S. D.*
Demographic and socioeconomic indicators			
Young Male	Proportion of male population aged 12–25 years old	11.07	5.91
Foreign	Proportion of foreign population	17.62	17.13
University	Proportion of population with university education or higher	21.30	9.68
Unempl	Proportion of unemployed population	10.06	5.72
House Own	Proportion of owned dwellings	70.16	18.85
No Sewage	Proportion of dwellings with no direct connection to a sewer	10.76	17.08
No Hotwater	Proportion of dwellings with no hot water	25.20	22.22
No Flush Toilet	Proportion of dwellings with no flush toilet	18.33	20.31
No Heating	Proportion of dwellings with no heating system	39.55	31.88
Pop Dens	Population density (square miles)	0.004	0.005
Land use indicators			
Pub Transp	Proportion of public transport per area	0.01	0.02
Pubs & Clubs	Proportion of pubs and bars per area	0.004	0.02
Offences (standardised offence ratios)			
Homicide	Homicide (log)	0.60	1.98
Assault	Assault (log)	2.79	2.54
Robbery	Robbery (log)	2.10	2.60
Thefts	Theft (log) (N = 354)	4.65	1.06
Drugs	Drug-related crimes (log)	1.31	2.32
Vandalism	Vandalism (log)	1.93	2.56

Table A3. Bivariate correlations for dependent and independent variables

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
1. Young people	1																
2. Foreign pop	–0.007	1															
	0.886																
3. Higher Educ	–0.256**	–0.405**	1														
	0.000	0.000															
4. Unempl	0.029	0.600**	–0.562**	1													
	0.578	0.000	0.000														
5. House Own	–0.337**	–0.113*	0.219**	–0.120*	1												
	0.000	0.029	0.000	0.020													
6. No Sewage	0.015	–0.358**	–0.109*	–0.138**	0.165**	1											
	0.767	0.000	0.035	0.008	0.001												
7. No Hotwater	0.029	–0.251**	–0.273**	0.136**	–0.166**	0.431**	1										
	0.581	0.000	0.000	0.009	0.001	0.000											
8. No Flush Toil	0.021	–0.524**	–0.079	–0.212**	0.113*	0.730**	0.547**	1									
	0.690	0.000	0.127	0.000	0.029	0.000	0.000										
9. No Heating	–0.045	–0.613**	0.021	–0.162**	0.037	0.451**	0.705**	0.647**									
	0.390	0.000	0.684	0.002	0.481	0.000	0.000	0.000									
10. Pop Dens	–0.007	0.536**	–0.128*	0.276**	–0.203**	–0.358*	–0.370**	–0.474**	–0.566**	1							
	0.887	0.000	0.013	0.000	0.000	0.000	0.000	0.000	0.000								
11. Pub Transp	–0.009	0.194**	0.109*	0.109*	–0.094	–0.212**	–0.060	–0.245**	–0.206**	0.271**	1						
	0.867	0.000	0.034	0.035	0.068	0.000	0.249	0.000	0.000	0.000							
12. Pubs & Clubs	–0.009	–0.023	0.176**	–0.055	–0.076	–0.073	–0.018	–0.086	–0.019	–0.21	0.334**	1					
	0.867	0.657	0.71	0.285	0.144	0.161	0.725	0.098	0.718	0.693	0.000						
13. Homicide	–0.030	0.160**	–0.017	0.133*	–0.078	–0.046	–0.007	–0.064	–0.114**	0.187**	0.179**	0.125*	1				
Ratio (log)	0.562	0.002	0.743	0.010	0.131	0.375	0.900	0.220	0.028	0.000	0.000	0.016					
14. Assault	–0.058	0.395**	–0.187**	0.389**	–0.217**	–0.269**	–0.011	–0.308**	–0.242**	0.387**	0.315**	0.168**	0.217**	1			
Ratio (log)	0.263	0.000	0.000	0.000	0.000	0.000	0.833	0.000	0.000	0.000	0.000	0.001	0.000				
15. Robbery	–0.004	0.312**	–0.087	0.269**	–0.269**	–0.236**	0.001	–0.282**	–0.225**	0.422**	0.419**	0.244**	0.107**	0.449**	1		
Ratio (log)	0.943	0.000	0.092	0.000	0.000	0.000	0.989	0.000	0.000	0.000	0.000	0.000	0.038	0.000			
16. Vandalism	–0.003	0.350**	–0.062	0.254**	–0.221**	–0.258**	–0.047	–0.287**	–0.285**	0.353**	0.443**	0.286**	0.198**	0.407**	0.522**	1	
Ratio (log)	0.954	0.000	0.231	0.000	0.000	0.000	0.365	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
17. Drugs Ratio	–0.022	0.344**	–0.146**	0.285**	–0.157**	–0.201**	–0.033	–0.215**	–0.217**	0.380**	0.300**	0.143**	0.256**	0.382**	0.365**	0.364**	1
(log)	0.672	0.000	0.005	0.000	0.002	0.000	0.522	0.000	0.000	0.000	0.000	0.006	0000	0.000	0.000	0.000	

Notes: *Correlation is significant at the 0.05 level, 2-tailed, **significant at the 0.01 level, 2-tailed, $N = 374$, variable TheftRatio(log) is not included since $N = 354$.

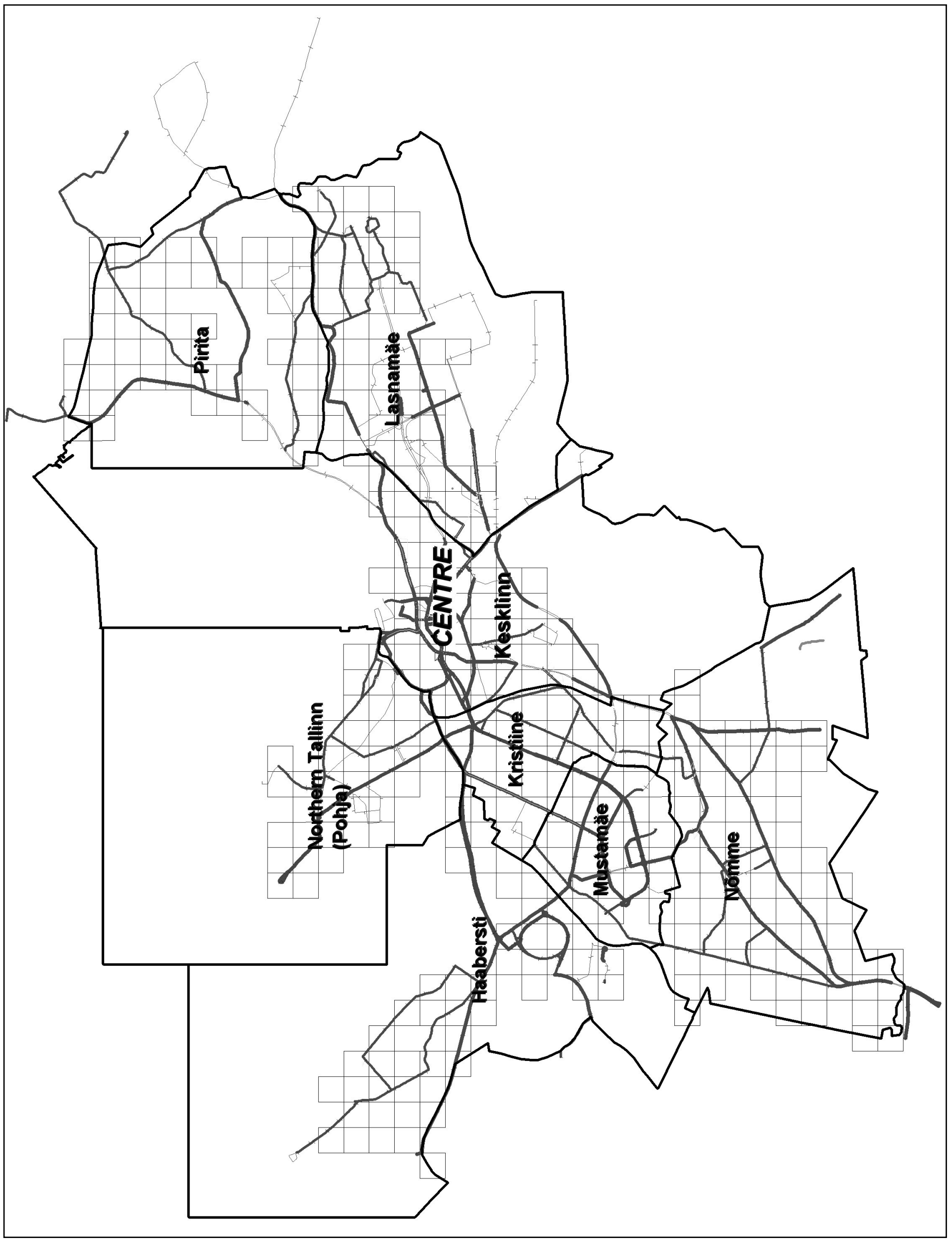

Figure A1. The study area

Scale: Grid squares are 500×500 metres.