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# Comparing spatial patterns of robbery: Evidence from a Western and an Eastern European city

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**In this paper, we test hypotheses about the spatial variation in rates of robbery in West and East European cities (Cologne, Germany and Tallinn, Estonia). This comparison represents an interesting case study because Tallinn is an example of former socialist cities which have undergone a period of profound political and socio-economic change since the country's independence in the early 1990s (including EU membership). These changes are expected to have implications for the level and composition of offences as well as their geographies. Using cross-sectional datasets, we examine whether or not levels and patterns of robbery in Tallinn follow similar processes to the ones found in Cologne applying GIS (Geographical Information System) and spatial statistical techniques. Findings show that although levels of robberies (rates) are higher in Tallinn than in Cologne, their geography (ratios) follows the same overlapping components of social contexts, as social disorganization and, particularly, routine activities.**


*Keywords:* Robbery, Space–time patterns, GIS, Tallinn, Cologne

## Introduction

Spatial analyses of predatory crimes have revealed strong concentrations of crime in central city areas and strong associations with non-residential and mixed land use as well as with indicators of deprivation and social exclusion, lending support to both the routine activity approach and social disorganization theory (e.g., Duffala, 1976; Sherman et al., 1989; Barker et al., 1993; Smith et al., 2000; Smith, 2003). Most studies on spatial patterns of urban violence have been pursued in cities in the United States or other Western industrialized countries, and little is known about crime and urban contexts in post-socialist cities experiencing the transition from a planned to a market economy. The contribution of this paper is to identify and compare space and time patterns of robbery in two different cities: Cologne, Germany, a Western European city, and Tallinn, Estonia, an Eastern European city. In this comparison, we particularly focus on the relative contribution of social disorganization and routine activity indicators to the explanation of robbery patterns.

These two cities have been chosen for the following reasons. In Western Europe and North America, cities have during past decades seen a shift from the industrial age to 'late modernity' (Giddens, 1990) or the 'informational' and 'network society' (Castells, 1989, 1996). *Cologne* is an excellent example of this shift because its economic basis has partly moved away from manufacturing to electronic media. Cologne is among the one hundred 'world cities' identified by Taylor et al. (2002) as being centres of a globalized world economy.

In Eastern European cities, these changes overlap with those stemming from the political and economic

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transformations after the end of the Soviet era. *Tallinn* is an example of Eastern European cities which have undergone a period of profound political, economic and social change since the country's independence in the early 1990s (Kährik, 2002; Ruoppila and Kährik, 2003) which is expected to have implications for the level and composition of offences as well as their geographies. For instance, social change has seen the emergence of a new geography of social differentiation linked to an increased economic polarisation. Evidence first from Western European cities, and later, from post-socialist Eastern European capital cities shows a contrast between relatively secure and well-paid jobs and those affected by the decline of traditional manufacturing industries. This in turn may lead to the emergence of areas that are characterised by social exclusion with particular social organisation that may lead to high levels of crime (Friedrichs et al., 2003; Murie and Musterd, 2004).

A second focus of this paper is on the space–time analysis of variations of criminal events at intra-urban levels. This perspective was until recently rare since detailed crime data did not exist or were of poor quality. This study is based on detailed geo-referenced crime databases for both cities, which were made feasible by the use of Geographic Information System (GIS) technology and spatial statistics techniques.

The structure of this paper is as follows. Section ''Robbery patterns: theoretical approaches, previous research and hypotheses'' discusses how urban geographies in general may shape predatory crime patterns, reviewing current spatial crime theories which have been developed with the Western experience in mind. Section ''Socio-spatial differentiation in Western capitalist and Eastern post-socialist cities'' frames Cologne and Tallinn as case study areas and characterises the cities' urban structure in relation to crime in more detail. Section ''Data'' introduces the data used for this paper. Section ''Results'' presents descriptive findings and results from regression analysis, followed by a concluding section ''Conclusion''.

## Robbery patterns: theoretical approaches, previous research and hypotheses

Studies on patterns of crime in Western European and North American cities are based on two major complementary theoretical approaches: social disorganisation (e.g., Shaw and McKay, 1942; Kornhauser, 1978; Sampson et al., 1997) and routine activity theories (e.g., Cohen and Felson, 1979; Sherman et al., 1989; Osgood et al., 1996). Social disorganisation theory suggests that structural disadvantage breeds crime. The main focus is placed on offenders and motivation. Studies based on social disorganization theory often use area-based indicators of poverty, ethnicity and residential stability and typically deal with expressive crimes. Many decades of studies following this approach have shown the effect of deprivation and social exclusion on the geographical distribution of offences and offenders in urban areas. More recent investigations suggested that social polarisation combined with the loss of social cohesion or collective efficacy have a significant effect on crime levels and the types of crime committed in different parts of the city (Hirschfield and Bowers, 1997; Sampson et al., 1997).

Routine activity theory, on the other hand, focuses on the dynamics of crime events. Crimes depend on the convergence in space and time of motivated offenders, suitable targets and absence of capable guardians (Cohen and Felson, 1979). Since the prediction of human interaction in space is very difficult to attain empirically, routine activity studies are often based on static measurements of a city's land use structure, such as commercial places, concentration of pubs/bars, public entertainment and transport nodes which determine human movement patterns over time (Anselin et al., 2000; Roncek and Maier, 1991).

Routine activity theory has been particularly useful in explaining the geography of acquisitive crimes, such as robbery. Sherman et al. (1989) suggested that clusters of robbery in Minneapolis, MN the US, were near each other (0.3 km), and that the vast majority were located on a limited number of main avenues. Also in the US, Duffala (1976) showed that robberies tend also to concentrate near convenience stores, close to vacant land or away from other commercial areas. This theory puts also a new emphasis on the meaning of *temporal* patterns of crime. Research has shown that for robberies in particular, the social interactions that take place in the city centre during nighttime are more important than the ones during day (see e.g., Smith, 2003).

There have more recently been attempts to combine the explanatory powers of both basic theoretical approaches. They showed evidence of the importance of both social disorganisation and routine activity theories to explain the geography of robbery in North American and Western European cities (Smith et al., 2000; Barker et al., 1993; Smith, 2003). For post-socialist cities in Eastern Europe, however, very few studies reported the nature of urban crime and very little is found particularly on robbery. We will now discuss some studies of crime patterns for socialist and post-socialist cities.

Smith (1989, p. 30) after examining social differentiation in several socialist cities suggests that crime 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''. Among the offenders, single rural migrants who no longer were ''subject to the traditional controls of family and community'' seemed to be overrepresented. Crime was said to be generated by particular land uses (e.g., Bartnicki, 1986) as well as conditions equivalent to 'social disorganisation', which seemed to be to some extent similar to the ones found in Western cities (despite the widespread agreement that socialist cities were generally characterised by low level of segregation). Some general reference to differences in intra-urban patterns in other socialist cities were also made by Gachechiladze (1990) and Clark and Wildner (2000).

Warsaw is however one of the few cities that has well-documented material on its intra-urban crime structure in the socialist era. In the 1970s 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 was particularly vulnerable to acquisitive crimes, such as robbery and thefts, after its re-development (Bartnicki, 1986, p. 240; French and Hamilton, 1979, p. 281). Dangschat (1987, p. 51) also refers to the existence of young offenders, violence and alcoholism in certain parts of this Polish city. After the end of Soviet domination, many Eastern European capital cities have experienced a rise of drug related offences and other illegal activities related to organised crime, such as human trafficking and prostitution (e.g., Juska et al., 2004; Aral et al., 2006) that might affect local conditions for all sorts of crime and also fear of crime. According to 2000's International Crime Victims Survey (ICVS), residents of Eastern European cities feel more often unsafe than those living in cities of Western Europe (Del Frate and Van Kesteren, 2004). In Vilnius, the capital of Lithuania, for instance, the largest concentration of social problems (alcoholism, drug addiction, homelessness) coincides with areas of high residential mobility, high levels of pollution and noise but also areas with mixed land use. People tend to feel safer in the outskirts of the city than in the city centre (Juskevicius, 2006, pp. 71–73).

Taken together, the existing literature on spatial crime patterns in socialist cities suggests that structural and social processes similar to Western cities have an impact on where predatory crime happens. However, previous research on socialist cities has not been advanced enough for proper hypothesis testing and thus precludes comparisons with results from Western cities. For the purpose of our comparative study, we follow the recent strand of Western research on crime and hypothesize that both social disorganization theory and routine activity theory can contribute to the explanation of spatial patterns of robbery. Hence, this study will test the following hypotheses:

(1) We expect robbery to be more frequent in socially disadvantaged and heterogeneous neighbourhoods, as predicted by social disorganization theory.
(2) Assuming principles of routine activity theory, we deem it likely that robbery will occur more frequently in the most central areas of the city, and particularly during nighttime.
(3) To the degree that non-residential, commercial land use pattern extend beyond the immediate city centre, we assume that robbery hot spots will follow this trend towards decentralization towards the periphery.
(4) As to the comparative dimension, we assume that the empirical results in the Eastern post-socialist city do not fundamentally differ from the findings in the Western capitalist city.

Before testing these assumptions empirically, we will describe the recent developments of the social geographies of our two cities in more detail.

## Socio-spatial differentiation in Western capitalist and Eastern post-socialist cities

### *Cologne*

Cologne is Germany's fourth largest city with a population just over one million, and is located in the Rhine-Ruhr area which is one of the largest conurbations in Europe. In recent research on world cities networks, Cologne ranks 7th within Germany and 24th within Europe (Taylor et al., 2002). Cologne has a long history as a major centre of commerce and industry and has in recent decades grappled with the transition to a post-industrial economy largely dominated by service industries. Cologne was particularly successful in recasting itself as one of the leading German media cities with more than 40,000 jobs in the media and IT sector in 2002 (City of Cologne, 2006). Traditional industries have dwindled or disappeared resulting in socio-economic problems such as high unemployment, especially among vulnerable sections of the urban population. The unemployment rate stood at 13% in 1999 (City of Cologne, 2000).

De-industrialization and the rise of post-industrial service sectors fueled processes of social and ethnic segregation (O'Loughlin and Friedrichs, 1996). Central areas close to the city centre have been subject to the process of gentrification, driven by the housing demands of young, well-educated single persons (Kecskes, 1997). Disadvantaged areas are therefore rare in the central parts of Cologne. Neighbourhoods with high concentrations of poor, unemployed residents and immigrants are mainly located in traditional working class areas adjacent to old, often dismantled industrial zones, and particularly in large, high-rising public housing areas situated at the outskirts of the city. Ethnic and social segregation is closely linked in these poverty areas. For example, nearly half of the non-German children in Cologne live in the two top deciles of poorest neighbourhoods (Oberwittler, 2007a). However, the levels of social and ethnic segregation and related urban problems are much less pronounced than in French and British cities (Oberwittler, 2007b).

As a major commercial and cultural centre and as a university city, Cologne's city centre and also some sub-centres are characterized by various kinds of non-residential land use such as shopping and entertainment which are potential factors in shaping the spatial distribution of robberies.

### *Tallinn*

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. In addition to long-time functions as seaport and capital city, Tallinn has seen the development of an IT sector in recent years. Of all EU member states' capital cities, Tallinn has the largest number of non-EU nationals: 28% of its population are not EU citizens, mostly Russians but also Ukrainians and Belarusians (Eurostat, 2006). During the period of Soviet control large numbers of Russians and other Soviet citizens came to Estonia, who after Estonia's independence did not qualify automatically for Estonian citizenship, neither did their offspring. As suggested by Aasland and Flotten (2001, p. 1024) not having citizenship is already ''a form of exclusion which may lead to a feeling of social exclusion as well''. Non-Estonians (particularly Russians) are over-represented in flats (e.g., in Lasnamäe and Northern Tallinn) while Estonians are concentrated in detached housing (e.g., in Pirita and Nõmme). Kährik (2002) suggest that although the pattern of ethnic differentiation has remained largely the same compared to the socialist times, poor non-Estonians started to move from the housing states to the lower quality flats whilst Estonians became even more concentrated in detached single housing areas. However, in countries like Estonia, where the transition from a planned to a market economy is still going on, socio-economic polarisation may not yet be fully evident. One of the reasons is that post-socialist cities have had from the start a lower level of socio-economic segregation than capitalist cities (French and Hamilton, 1979; Dangschat, 1987; for a review, see Smith, 1989) but also that they are changing in a much slower pace than Western cities (Sýkora, 1999).

Gentrification has been taking place in many post-socialist cities (Kovács, 1998; Sýkora, 1999) and in Tallinn; inner-city neighbourhoods also show some indications of such a process. Tallinn's inner city neighbourhoods concentrate more wealthy residents than in the past, but according to Ruoppila and Kährik (2003), they are far from being homogenous neighbourhoods.

Moreover, inhabitants of Tallinn's central areas share spaces with a blooming service sector that employs 7 out of 10 inhabitants of Tallinn (Tallinn municipality, 2005). As in other post-socialist cities (Rudolph and Brade, 2005; Nuissl and Rink, 2005), new large commercial and business services were established in Tallinn since early 1990s. Banks, governmental and private institutions and other businesses attract a large part of the labour force and daily visitors that populate the streets in the most central areas during daytime. The city centre also shows the highest concentration of restaurants, night clubs and bars which attract people, particularly youth, to the inner city areas, and particularly during nighttime. Thus, important structural features assumed by routine activity theory to attract predatory crimes are present in the city centre of Tallinn, as they are in Cologne.

Although the majority of shopping centres and large department stores are nowadays within a radius of not more than 3 km from city centre, some of these developments have also resulted in the growth of transport axes outside the inner city areas (e.g., towards the airport). Whilst public transport dominated during the Soviet era, cars are nowadays by far the most important transport mode for commuters in Tallinn. People who are mobile may prefer the service outlet, which is most convenient to their workplace instead of using the services near where they live. This then leads to the decline of small local shops and hence to the elimination of these locales as sites for offences, displacing the risk for robbery to service outlets instead.

## Data

The dependent variable in the following analyses are cases of robbery registered by the police in Tallinn and Cologne. In Cologne, we are using 'calls to the police' data gathered during a 12 months period between May 1999 and April 2000. These calls are immediately geocoded by the police using *xy*-coordinates. Five percent of cases were not geocoded or were located outside spatial units (including some large in parks or forests). While these 'calls-for-service' data share the well-known problems of all police recorded crime indicators, they nevertheless represent the most complete and unscreened recording of crimes once a victim or third person has decided to turn to the police in a case of emergency (for detailed discussions, see Sherman et al., 1989, pp. 33–36; Warner and Pierce, 1993, p. 496).

For Tallinn, registration data on robberies between June 2004 and May 2005 were obtained from the Central Criminal Police. This 1-year geo-referenced database contains data on type of offence, crime code, when the crime occurred (date and time interval), crime location by street name, house or building number as well as the respective *xy*-coordinates. Seven hundred and twenty four cases out of 905 robberies were mapped in Tallinn; this translates into mismatch of 20% (more than two-thirds of these robberies took place during the nighttime) which may potentially distort models for Tallinn. An Appendix summarises the main characteristics of the study areas and databases used in this analysis.

Independent variables in both cities are commonly used socio-demographic and land use data provided by the local statistical offices (see Appendix). The cross-national comparison is rendered more difficult by the fact that some dimensions of socio-demographic structures are represented by different indicators in both cities. In particular, as recent census data do not exist in Germany, most information in Cologne comes from official population registers which however are very reliable, or are generated in the course of local government action. For example, deprivation is measured in Cologne by the percentage of residents receiving welfare benefit, whereas in Tallinn, we use the average income of residents based on 2000 census data. On the whole, however, we trust that the data available for comparative analyses are valid measurements of the same latent dimensions relating to social disorganization and routine activity theories, respectively.

## Results

### *Temporal and spatial patterns of robberies*

We start the empirical analysis by looking at the temporal and spatial distribution of robbery in Cologne and Tallinn. *Figure 1* shows the diurnal fluctuations of robbery. Very similar patterns emerge: the frequency of robberies is lowest during morning hours (ca. 6–10 h) and then increases steadily during the day and evening. In Cologne, there is a marked peak of cases around 18 h which co-occurs with the evening rush hour and the closing time of shops. In Tallin, robberies peak much later at night suggesting a possible relationship with leisure and entertainment activities. The common feature in both cities is that robberies happen much more often during evening and night hours than during the day. The increase of robberies during night hours seems slightly more pronounced in Tallinn.

In order to explore the spatial distribution of robberies, we dichotomized the geographical units into belonging to the 'downtown' areas (ca. 2.5–3.0% of the total area in

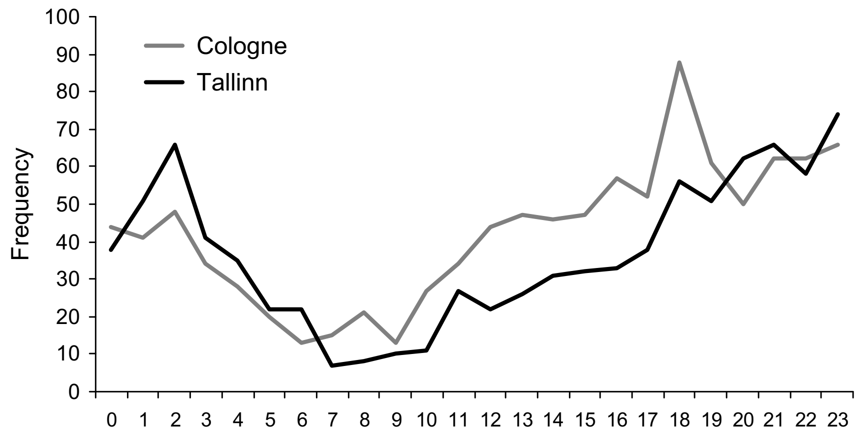


**Figure 1** Robbery by hour: Cologne and Tallinn.

both cities, comprising the historic city centres) or to the rest of the cities. Daytime robbery rates (per 100,000 residents) are around five times higher and nighttime robbery rates are around six times higher in the downtown areas of Cologne and Tallinn than elsewhere. In downtown Tallinn, robberies are twice as likely happen during night hours; in downtown Cologne, robberies during nighttime are only 1.2 times more likely than during daytime. However, it has to be stressed that the resident population is not a perfect denominator for crime because central areas usually have relatively low numbers of resident population but very high numbers of non-resident population (Oberwittler, 2004). Nevertheless, these descriptive findings lend support to basic assumptions of routine activity theory, i.e. the dependence of direct-contact predatory crimes on the convergence of potential victims and offenders in public spaces, particularly in the course of leisure time activities.

One way to identify the spatial concentrations of offences in more detail is to apply cluster statistical techniques. The Nearest Neighbour Hierarchical (NNH)[1] used here is a clustering technique that identifies groups of incidents that are spatially close (Levine, 2002). The NNH technique uses a nearest neighbour method that defines a threshold distance and compares the threshold to the distances for all pair of points. Only points that are closer to one or more other points than the threshold distance are selected for clustering. In this first criterion, we have chosen 500 m for the threshold distance. However, the number of clusters is dependent on the threshold distance and the minimum number of points in each cluster. Keeping exactly the same clustering criteria for Cologne and Tallinn, we ended up with 20 significant hotspots for Cologne and 24 for Tallinn. *Figure 2a and b* illustrates the first-order clusters of robbery for Cologne and Tallinn.

What is evident in this pattern is how clusters of robbery are concentrated in the inner city areas for both Cologne and Tallinn, and particularly in the case of Tallinn, they follow 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 places (for similar results, see Brantingham and Brantingham, 1991). Apart from the inner city, few areas in densely occupied parts of the Tallinn are also targets for robbery: Mustamäe, Northern Tallinn and Lasnamäe. In Cologne, these areas are among others Mühlheim and Kalk on the right-hand side of the river Rhine, and Nippes, Ehrenfeld and Chorweiler on the left-hand side of the Rhine.

*Regression models*

For the purpose of modelling in regression analysis, we use standardised robbery ratios (SRR) instead of conventional robbery rates per 100,000 inhabitants.[2] Standardised robbery ratios are designed to identify districts that run a relative high risk for robberies, taking into account the overall distribution of robberies in each city. SRR is a useful way of representing data for a set of regions where the areas differ in size (absolute values would tend to over-emphasise large areal units) and where it is necessary to allow for differences in population characteristics (see, e.g., Ceccato et al., 2002). SRR is a measure of relative risk. Thus, a region with a SRR of 200, for instance, has a relative risk for robbery twice that to be expected given its number of inhabitants (*Figure 3*).

The regression analysis was implemented using GeoDa 0.9.5-i5 (Anselin, 2004) since the software has regression modelling capabilities with a range of diagnostics that are not available in standard statistical packages. The set of standardised robbery ratio values shows a highly skewed distribution. The raw ratios were transformed (taking the natural log) to produce results that come closer to normality. The distribution of the independent variables was checked against the dependent variable using ‘partial plots’ and at least for some of them, log

[1] For this example, CrimeStat III was utilised. This is a spatial statistics program for the analysis of offence incident locations, which is available at http://www.icpsr.umich.edu/CRIMESTAT/.

[2] The Standardised robbery ratio for census tracts $i$ in city $N$ is given by $SRR(i) = O(i)/E(i) \times 100$, where $O(i)$ is the observed number of cases of robbery and $E(i)$ is the expected number of cases of robbery. An average offence rate was obtained by dividing the total number of robberies by the total size of the chosen denominator (total resident population). For each area $i$, this average rate is multiplied by the size of the chosen denominator in area $i$ to yield $E(i)$.


**Figure 2** (a) Hot spots of robbery in Cologne and (b) hot spots of robbery in Tallinn.

transformation was required, too (the Appendix indicates the transformation for the significant variables). In order to test for spatial autocorrelation on the residuals, two kinds of weight matrices were used. For Tallinn, a row standardized binary weight matrix ($W$) was used that comprised non-zero entries where $i$ and $j$ refer to areas that are adjacent and the Standardised Robbery Ratio data refer to the same district ('Queen'-adjacency, first-order contiguity criterion). Since the map of Cologne was composed mostly of non-adjacent census tracts (with many 'islands'), we built a weight matrix based on distance weight. To make the weight matrices as comparable as possible, the distance threshold was the minimum default suggested by GeoDa after defining co-ordinates and distance metric

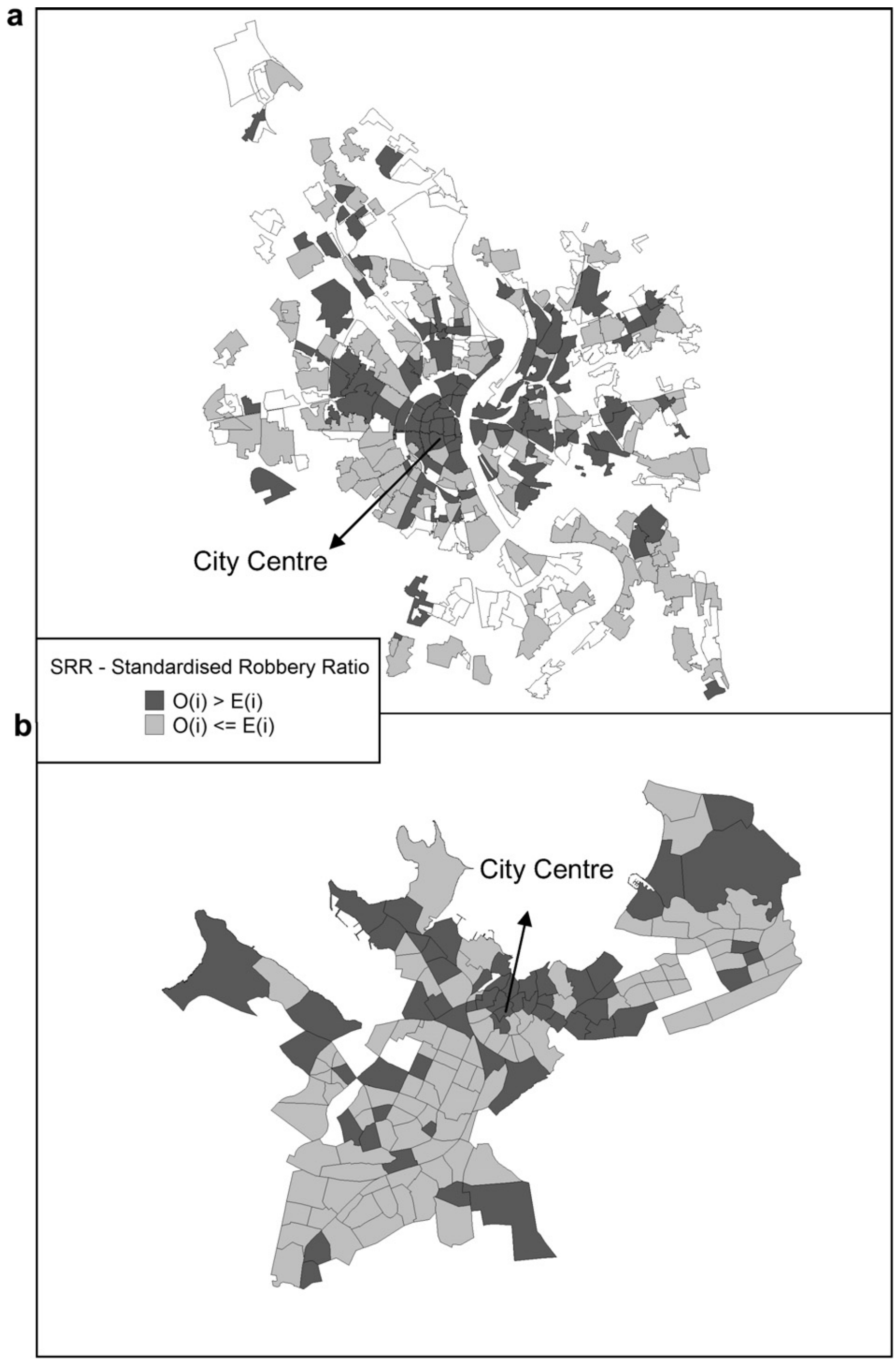


**Figure 3** SRR Cologne (a) and SRR Tallinn (b).

(including mostly first- and second-order neighbours). Both weight matrices are row-standardised, which means that the spatial parameters are comparable.

The modelling strategy was the following. All covariates are inserted in the model (see Appendix) and the results are presented in *Tables 1 and 2*. However, to check for the impact of social disorganisation risk factors in comparison to routine activity covariates, a stepwise procedure was used. We focus the interpretation of the statistical models on the question whether the relative contribution of the two blocks of covariates (routine activity and social disorganisation variables) to the explanation of robbery ratios is similar or different in both cities.

*Tables 1 and 2* show the results of the regression analysis for robbery ratios and the significant variables at the 1% (***), 5% (**), and 10% (*) levels and their transformation. We note that despite data transformations to correct for skewness of the dependent variable, non-normality of residuals was still a problem, particularly in the models of day/nighttime robbery. For Tallinn, the OLS regression model diagnostics revealed significant

**Table 1 OLS regression of robbery ratios – Cologne 1999/2000**

| | Total robbery (log) | | Daytime (log) | | Nighttime (log) | |
|---|---|---|---|---|---|---|
| | **B [stand. err]** | ***t*-value** | **B [stand.err]** | ***t*-value** | **B [stand.err]** | ***t*-value** |
| Intercept | 1.47 [1.03] | 1.42 | 1.16 [1.15] | 1.01 | −0.37 [1.17] | −0.31 |
| DistCentre | −0.0001$^{**}$ [−0.00004] | −2.32 | −0.0001$^{**}$ [−0.00005] | −2.03 | −0.00006ns. [−0.00006] | −1.37 |
| ComInfra | 1.35$^{***}$ [0.38] | 3.58 | 1.51$^{***}$ [0.42] | 3.60 | 0.91$^{**}$ [0.43] | 2.12 |
| Pubs&Clubs | 0.30$^{**}$ [0.13] | 2.30 | 0.39$^{***}$ [0.14] | 2.73 | 0.30$^{**}$ [0.15] | 2.02 |
| ResPopDensity | −0.02$^{***}$ [0.004] | −4.07 | −0.02$^{***}$ [0.005] | −3.40 | −0.001ns. [0.005] | −0.31 |
| YoungMale | 0.05ns. [0.04] | 1.09 | 0.05ns. [0.05] | 1.06 | 0.06ns. [0.06] | 1.15 |
| ElderlyPop | 0.03$^{*}$ [0.02] | 1.78 | 0.03ns. [0.02] | 1.35 | 0.01ns. [0.02] | 0.67 |
| WelfRec | 0.68$^{***}$ [0.21] | 3.23 | 0.84$^{***}$ [0.23] | 3.59 | 0.15ns. [0.24] | 0.63 |
| Non-German | 0.44$^{*}$ [0.26] | 1.70 | 0.15ns. [0.28] | 0.52 | 0.72$^{**}$ [0.29] | 2.42 |
| R2 X 100 | 28.3% | | 27.05% | | 23.3% | |
| Multicollinearity Condition number | 27.90 | | 27.91 | | 27.91 | |
| Jarque-Bera | 1.19ns. | | 7.96$^{**}$ | | 13.07$^{**}$ | |
| Breusch-Pagan test | 51.91$^{***}$ | | 31.15$^{***}$ | | 28.32$^{***}$ | |
| Lagrange Multiplier (error) | 0.17ns. | | 0.34ns. | | 2.38ns. | |

[standard errors], $^{***}$ significant at 99%, $^{**}$ significant at 95%, $^{*}$ significant at 90%, $N = 323$.

**Table 2 Regression results of robbery ratios – Tallinn 2004/2005**

| | OLS – total robbery | | OLS – day robbery | | OLS – night robbery | |
|---|---|---|---|---|---|---|
| | **B [stand. err]** | ***t*-value** | **B [stand. err]** | ***t*-value** | **B [stand. err]** | ***t*-value** |
| Intercept | 1.76 [2.09] | 0.84 | −6.34 [2.19] | −2.88 | 2.37 [2.42] | 0.98 |
| DistCentre | −0.05ns. [0.07] | −0.68 | −0.06ns. [0.07] | −0.91 | −0.07ns. [0.08] | −0.84 |
| EmpPopDensity | 0.58$^{***}$ [0.19] | 3.05 | 0.68$^{***}$ [0.20] | 3.41 | 0.53$^{**}$ [0.22] | 2.41 |
| Pubs& Clubs | 0.55$^{***}$ [0.16] | 3.38 | 0.49$^{***}$ [0.17] | 2.92 | 0.54$^{***}$ [0.19] | 2.88 |
| PubTransp | 0.19ns. [0.28] | 0.69 | 0.32ns. [0.29] | 1.13 | 0.16ns. [0.32] | 0.49 |
| ResPopDensity | −0.37$^{***}$ [0.13] | −2.78 | 0.09ns. [0.14] | 0.64 | −0.29$^{*}$ [0.16] | −1.88 |
| YoungMale | −0.03ns. [0.04] | −0.66 | 0.13$^{***}$ [0.04] | 2.77 | −0.07ns. [0.05] | −1.46 |
| ElderlyPop | −0.05ns. [0.03] | −1.43 | −0.03ns. [0.04] | −0.73 | −0.04ns. [0.04] | −1.06 |
| AveIncome | −0.00008ns. [0.00001] | −0.74 | −0.00002ns. [0.00002] | −1.64 | −0.00004ns. [0.00001] | −0.31 |
| ForeigLang | 0.03$^{***}$ [0.009] | 3.63 | 0.03$^{***}$ [0.009] | 3.57 | 0.02$^{**}$ [0.01] | 2.08 |
| W_Y | | | | | | |
| R2 X 100 | 39.3% | | 42.9% | | 31.1% | |
| Multicollinearity Condition number | 44.49 | | 44.49 | | 44.49 | |
| Jarque-Bera | 7.52$^{**}$ | | 1.21ns. | | 4.87$^{*}$ | |
| Breusch–Pagan test | 0.19ns. | | 1.95ns. | | 1.42ns. | |
| Lagrange Multiplier (error) | 18.97 | | 30.41$^{***}$ | | 4.25$^{**}$ | |

[standard errors], $^{***}$ significant at 99%, $^{**}$ significant at 95%, $^{*}$ significant at 90%, $N = 158$.

spatial autocorrelation on the residuals. For Tallinn, spatial lag and spatial errors models were fitted in order to address these problems, and in all cases, the spatial lag model had a slightly better fit (based on Log likelihood – LIK, $R^2$ and variables' performance as suggested by Anselin, 2004) than the OLS and error models (to make it to compare, we show only the OLS results). Heteroskedasticity also remained a problem in most of the models, which implies that residuals do not have a constant variance and inferences on the results should be carefully done. The models for both Tallinn and Cologne show that the signs of the coefficients are as expected for both social disorganisation and routine activity variables.

The discussion of the results is divided into two parts. First, we check whether our hypotheses are supported in both Tallinn and Cologne by looking at performance of covariates of social disorganisation and routine activity theory in the model of total robbery ratios. Then, we discuss the particular day/nighttime patterns of robbery in these two cities by looking at whether the two sets of covariates perform differently from day to night in the two cities.

Centrality and non-residential land use is associated with a higher risk of robbery. The hot spot analysis had already shown that most of the robberies occur in central areas of the cities. This is confirmed in the models by the significance and expected sign of the following routine activity variables: employed population, pubs and clubs (Tallinn) and distance to the city centre, pubs and clubs and commercial infrastructure (Cologne). However, as the geography of clusters show (*Figure 2*a and b), hot spots of robbery are also found outside the city centre, both in Cologne and Tallinn, following main roads, stations and local centres, in other words, areas with mixed land use in residential areas.

Robbery tends to follow the geography of the most socially disorganised neighbourhoods, measured by social disadvantage and non-native origin. Indicators of deprivation come out as significant in the total robbery model for Cologne (welfare recipients). In Tallinn, the proportion of non-native residents is a significant predictor. Outer city areas with a high percentage of foreigners also have a high risk of robbery. This may be indicative of a lack of social stability or a high level of social disorganisation (Shaw and McKay, 1942). It is, however, against our expectation that lower income is not a significant predictor for Tallinn. We looked at a map of residuals (positive ones, areas where the offence pattern is under-predicted by the regression model) for clues but did not find a clear pattern. Both in Cologne and Tallinn, most of the areas with positive residuals are composed of residential areas with some mixed land use.

Both in Cologne and in Tallinn, routine activity variables are by far the most important type of covariates in explaining the variation in standardised robbery ratios, compared to social disorganisation variables. By looking at blockwise $R^2$, social disorganisation variables explain 10% of the variation of robbery ratios in Tallinn. As soon as land use variables are entered into the model, the explained variance jumps to 37% in the total robbery model and shows nearly 40% in the daytime model. In Cologne, too, routine activity predictors were more important than social disorganisation covariates, explaining alone nearly 20% (out of 27%) of the variation of total robbery ratios. The strategy of entering the variables stepwise into the models proved efficient to flag for evidence in favour of routine activity theory and to the detriment of social disorganisation variables.

An interesting additional finding is that higher robbery ratios are found in census tracts of low resident population density. This could be explained by the effect of informal guardianship which may be tighter in densely populated areas and weaker in low density areas. Similar results have been reported by Sampson and Raudenbush (1999, p. 629), Morenoff et al. (2001, p. 540) and Smith et al. (2000, p. 499).

The models predicting daytime and nighttime distributions of robberies are on the whole quite similar and do not lend much support to our assumption that routine activity variables are more salient for explaining nighttime distributions. Judged by the blockwise $R^2$ values, the models for daytime and nighttime robbery ratios are dominated by routine activity and social disorganisation dimensions in similar ways. There are, however, some differences in details which seem worth mentioning. In Tallinn, the coefficient of pubs and clubs increases by 37% from 0.38 to 0.52 when switching from daytime to nighttime robberies, which is according to our hypotheses. However, considering the overlapping standard errors of these coefficients, this difference in slopes is not significant. In Cologne, in contrast, the coefficient of pubs and clubs is weaker in the nighttime model compared to the daytime model contrary to our expectations. On the other hand, the proportion of non-native inhabitants is non-significant for daytime robberies but relatively strong for nighttime robberies.

## Conclusion

This paper has reported empirical findings about spatial variations in rates of robbery in the cities of Cologne, Germany and Tallinn, Estonia. The novelty of this paper is the attempt to compare crime patterns in cities that until recently were embedded in two different political, cultural and socio-economic contexts. Since very little previous research exists on Eastern European cities, we started by examining whether or not levels and patterns of robbery in Tallinn, a post-socialist city in transition to market economy, follow similar processes to the ones found in Cologne, a typical Western European city.

Based on the evidence gathered in this study, we can conclude that although robbery rates in Tallinn are higher than in Cologne, their geography and the factors that underlie such geography, are similar for both cities. Robbery is a phenomenon typical of central urban areas or areas of mixed land use. Clusters of robbery are concentrated in the inner city areas for both Cologne and Tallinn, and particularly in the case of Tallinn, they follow main roads, stations and local centres. In both cities, the geography of robbery is more associated with covariates of routine activities (e.g., pubs and clubs) than social disorganisation variables (e.g., welfare recipients or non-native residents) which, however, also have a significant contribution. Results also show that there are no major differences between significant covariates in the day and nighttime distribution of robbery. Thus, the results presented in this paper provide support for the generalizibility of spatial theories of crime from the ‘West’ to Eastern European cities.

This article also makes a contribution to the way crime data (until recently unavailable in Tallinn at co-ordinate level) can be aggregated in geographical census tracts and further analysed using GIS and regression models – information that is crucial for local police forces in defining long term crime prevention measures. Since some of the results may be dependent on the unit of analysis, future studies should check the effect of size, shape and number of census tracts on modelling robbery patterns.

This analysis shares however limitations with other cross-sectional analyses using aggregated data on 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 use data covering robbery for several years. Since in many post-socialist cities rapid spatial differentiation is still taking place, future studies should focus on modeling the cities' criminogenic conditions over time. The issue of high crime areas as a path dependency phenomenon could be explored using long-term individual data series (such as data on offence, victim, and offender). One way is to set up a multilevel modelling framework based on the integration of longitudinal individual data and aggregate level data (e.g., indicators of census tracts structural conditions). Thus, one of the main challenges is to elucidate the processes through which land use and socio-economic variables interact and influence levels of crimes in different neighbourhoods.

## Appendix A. Characteristics of the study areas and dataset

| Cologne | | Tallinn | |
|---|---|---|---|
| *Characteristics of study areas* | | | |
| Number of inhabitants | 988,766 (2006) | 400,911 (2007) | |
| Population density | 2443 km$^2$ (2006) | 2506 km$^2$ (2007) | |
| *Type of data source* | | | |
| Offences | Robbery (Calls to the police, May 1999 to April 2000). Total: 964 records (5.2% of cases not geocoded or located outside spatial units) | Robbery (Police records between June 2004 and May 2005) Total: 905 records (20% of cases not geocoded or located outside spatial units) | Central Criminal Police in Tallinn, Cologne Police Headquarters |
| *Social disorganisation* risk factors | Proportions of<br>Male population aged 18–24<br>Population 60 years old and over<br>Welfare receivers (log)<br>Non-German population (log) | Proportion of<br>Male population aged 18–27<br>Population 65 years old and over<br>Population with mother tongue other than Estonian<br>Average income per unit (Estonia Krooni) | Tallinn municipality, Cologne City Council |
| *Land use/routine activity factors* | Distance in meter *xy*-centroid to city centre<br>Commercial infrastructure per km$^2$ (log)<br>Pubs/restaurants/cafes per km$^2$ (log)<br>Resident population density ($^2\surd$) | Distance in meter *xy*-centroid of census tract to city centre<br>Pubs/restaurants per km$^2$ (log)<br>Bus/train/tram stations per km$^2$ (log)<br>Employed daily population per km$^2$ (log)<br>Resident population density (log) | Tallinn municipality, Cologne City Council |
| *Spatial units* | 323 units, Resident population average per unit: 3127, minimum: 52, maximum: 20,382, Standard deviation: 3102 | 158 units, Resident population average per unit: 1459, minimum: 23, maximum: 10,639, Standard deviation: 1793 | Tallinn municipality, Cologne City Council |

Robbery definition in Tallinn: According to 2002's Estonian penal code Robbery, takes place when a person who by using violence takes away movable property of another with the intention of illegal appropriation. Robbery definition in Cologne: According to the German Penal Code (Art. 249), a robbery takes place if a person takes away with the intention of illegal appropriation a movable property of another person by force or by threatening with force.

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