Clusters of Urban Crime and Safety in Transport Nodes

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Abstract

The objective of the thesis is to provide a better understanding of the safety conditions in urban environments, particularly related to those found in transport nodes, in this case, underground stations, and surrounding areas[1]. First, the study starts with an analysis of the overall city, identifying concentrations of crime in the urban fabric and then focusing on the criminogenic conditions at and around underground stations. The analysis combines the use of Geographical Information Systems (GIS), statistical techniques and data of different types and sources. Regression models were used to assess the importance of the environmental attributes of underground stations on crime rates. Findings show that violent and property crimes show different hotspots at different times. Crime patterns tend to follow people's scheduled patterns of routine activity. The socio-economic composition of the surrounding environment of the stations has a significant impact on crime at these transport nodes, but more important were attributes of the physical and social environment at the stations. For instance, low guardianship and poor visibility at the stations together with mixed land-uses in the surrounding areas induced crime rates at the stations. It is therefore suggested that intervention to improve safety conditions at the stations should focus on a holistic approach, taking into account the station and surrounding areas, but also being aware of crime variation on specific places at specific times.

Acknowledgements

Contents

Abstract

Acknowledgements

Contents

List of tables and Figures

List of tables and Figures

Chapter 1 - Introduction to the thesis

The thesis is composed of three articles:

> Article 1 - Uittenbogaard, A.C., and Ceccato, V. (2012). Space-Time Clusters of crime in Stockholm, Sweden. *Review of European Studies*, Vol. 4 (5), p.148-156. (*doi*: 10.5539/res.v4n5p148)

> Article 2 - Ceccato, V., Uittenbogaard, A.C., and Bamzar, R. (2011). Safety in Stockholm's underground stations: the importance of environmental attributes and context. *Security Journal. (doi:* 10.1057/sj.2011.32)

> Article 3 - Uittenbogaard, A.C., and Ceccato, V. (ff). Making transport nodes safer: an agenda for action in underground stations in Stockholm. *European Journal on Criminal Policy and Research,* submitted.

This section provides an introduction to the main themes dealt with in the articles that constitute the thesis. It sets out to provide basic concepts and make clear the relevance of the research questions posed in each article. First, the importance of safe urban environments is discussed as a significant dimension of urban quality of urban environments. Then, the theoretical background for the analysis of crime and safety is reviewed. An introduction to the basics of the method used in the study is presented in the following section. This introductory section ends with a summary of the results, limitations and reflections for future research.

1.1 Objective and background

Safety is one of the general concerns in modern societies. Safety can largely influence ones' daily life and behavior. Being able to live in a safe environment is of high value. Equally important is to have access to safe public transportation. Citizens move around between home and work and other daily activities by foot, using buses, trains, undergrounds and cars. For those who use public transportation, individuals bundle their paths (Hägerstrand, 1972) at specific points in urban space in so-called 'transport nodes'. Regardless of where they go, individuals are exposed to environments with differentiated levels of risk of crime.

Crime and victimization, as indicators of a lack of safety, have been studied by many disciplines (e.g. culture: Sellin, 1938; sociology: Erikson, 1961; politics: Cohen, 1996; economics: Machin and Meghir, 2004; Sjoquist, 1973; philosophical considerations: Lough, 1986; power relations: O'Malley, 2006) but, according to Saville and Kruger (2012), they have so far been absent from the contemporary debate on sustainability[2] (but see e.g., Cozens, 2007; Ceccato and Lukyte, 2011). Yet, it is difficult to think in terms of sustainable cities without considering crime and safety in the design, planning and development process.

Many of today's urban policies reflect the need for long-term planning and sustainable living with the aim of securing the quality of life for future generations. The sustainability of a community and a good quality of is closely related to the extent of crime in the city (Raco, 2007).

Safety affects all dimensions of urban sustainability. Living with crime and risk of victimization affect both the psychological and physical health and well being of an individual (e.g. Stafford et al., 2007; Koss et al., 1991; Wilkinson et al., 2008), not the least when these risks are high and motivate one to take unwanted decisions, such as moving out or changing travelling routes. Crime is now understood to be one of the main factors which explain why citizens move (Cullen and Levitt, 1999). For instance, if an inner city area is criminogenic, residents may feel motivated to move considerable distances to suburban areas despite the fact that this means increased expense and longer distances to travel, a higher dependence of car use but also poor tax basis for those who do not have the choice to move, in addition to being subject to higher taxation in the area they move into.

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[2] The most common acknowledged definition of sustainability combines three fields of development: environment, social, and economical. Sustainability is about balancing these three pillars: economic growth, environmental management, social equity. Originally defined as: "development that meets the needs of current generations without comprising the ability of future generations to meet their own needs (WCED, 1987, p.45). Safety is a central part of sustainability; it is included in the aim to provide access to nature, growth, and increased life quality for now and for later. Being safe should be regarded as one of the preconditions for sustainability (Saville and Kruger, 2012), when in danger or under threat there is no possibility to provide access to nature and public resources, neither is economic growth plausible but rather constraint by crime, nor can social equity be achieved because danger of crime restricts movements and actions.

In the context of this study safety is understood in direct relation to risks of crime and victimization. This thesis investigates the extent to which the concentration of crime varies over time and space in urban areas. It interrogates how crime is affected by the city environment? The study raises the question of how the risk of being a victim of crime in public transportation can be tackled. The paper demonstrates the importance of establishing a link between safety, urban environments and planning. The study works to show that safe public transportation positively affect the health and well being of citizens by providing alternatives to car usage. In turn, this has a positive impact on the development of a city, via the provision of safe access to areas and services.

The most significant impact of this thesis is in contributing towards a better understanding of the safety conditions in urban environments, particularly related to transport nodes. Transport nodes are here defined as those places where people come together to (des)embark on a transportation in order to reach a new destination. Transport nodes therefore exist not only off a stop or station but also the immediate surrounding environment. Transport nodes can be bus stops, underground stations or larger structures where several transportation modes come together, such as a central station (Ceccato, 2009). The use of the concept "transport node" is, in this study, limited to the analysis of underground stations. Analysing patterns of crime in these environments provides evidence of patterns of regularities of high risk areas, and therewith provide a legitimate basis for intervention. The study also points towards the need for crime prevention strategies to take into account and to include the influence of urban physical and social environments at and surrounding underground stations in relation to crime levels in the city.

Furthermore, the study explores several methods for identifying and analysing the concentration of crime patterns using Geographical Information Systems (GIS), statistical techniques and data of different types. Crime analysis and mapping of crime data contributes significantly to the understanding of crime patterns and its variations (Hirschfield and Bowers, 2001). The data used in the analyses vary from qualitative observations from the fieldwork to secondary data sources, such as police recorded crime and georeferenced demographic and socio-economic data. GIS is used for mapping offence records to a geographically reference system (here the national Swedish x,y-coordinate system) and attributes and demographics surrounding the underground stations. GIS is used to perform simple spatial analysis, such as query, buffer analyses and SQL queries. For instance, a buffer analysis enables the possibility to identify the number of objects or underlying aspects within a predefined ranged of the original object. Correlation analyses and regression models (Ordinary Least Square, OLS) are used to identify relationships between the environment and crime levels but also the explanatory power of environmental attributes to 'explain' the variation of crime rates.

The capital of Sweden, Stockholm, is used as case study. Most of the recent literature on crime and safety in urban environments is still based on evidence from the United States or

United Kingdom. There is a need for more research to be undertaken in less understood and widely unrepresented areas around the world. Findings from a Scandinavian perspective are particularly important, as previous research in this region is now outdated or missing. Furthermore, the case of a northern European city provides an extra-ordinary background as compared to other European countries because of the expected influence climate differences may have on individual's daily lives and habits over time. The cold, dark winters and sunny summers experienced in Scandinavia may have some effect on crime levels and geography.

1.2 The dynamics of urban crime

> *"For too long cities have been seen in a negative light as*
> *centers of high crime and poverty …"*
> Rio+20 Conference

Urban places are complex systems. Cities show dynamics in all kinds of matters, there is always something happening at any given time as activities are performed around the clock. People move around in all directions and with different aims. These movements are partly directed by the urban fabric and infrastructure available to citizens. City planning provides a direct link between the created space, accessibility and safety. Urban planning is the backdrop on which desired safety is generated and on which possible unwanted crimes may evolve. Safety and urban planning combine in a contribution for sustainable planning.

Table 1 – Main theories in the thesis.

	Social	Environment	Local	City-level
Routine Activity	●		●	●
Social Disorganization	●		●	●
Rational Choice	●	●	●	
Broken-Window		●	●	
Defensible Space		●	●	
CPTED		●	●	

Crime events and offences are not randomly distributed over space. Researchers have long searched for explanations of why certain places have more crime than others. The influence of the physical environment on human activities and consequently on crime causation is unquestionable (e.g., Newman, 1972, Wilson and Kelling, 1982,). Poor social control combined with other social and economic characteristics has a direct effect on crime and victimization (e.g., Shaw and McKay, 1942, Wikström, 1990). Below, a number of different theories of urban criminology are discussed and presented in combination with each other, rather than competing theories, to explain and analyse levels of crime and crime patterns. Each theory is linked to different (but also overlapping) aspects of urban crime and its underlying factors (see Table 1). Certain social aspects that influence crime are more pronounced in specific theories, while other theories focus more on explaining crime by

means of differences in the urban environment which affects people's routine activity. Different theories can also relate to different aspects of crime, such as local problems (e.g. neighbourhood) and crime concentrations related to more global issues (such as at city level).

The importance of the environment is suggested to be of high importance for surveillance opportunities and visibility in a place. The *defensible space theory* defines the lay-out of a space as the possibilities for control and prevention. Newman (1972) presented a comprehensive view on how different spaces can enhance visibility and create direct and in particularly indirect social control. As suggested in the concept, an open lay-out of a place provides more opportunities for control and surveillance. Placing housing blocks with windows to the street, creates indirect social control. Indirect social control is also enhanced by applying softer boundaries between public and private spaces, as to make users of both spaces more responsible for events happening outside their own private space. Visibility and surveillance also proved to be one of the main variables explaining crime variations at the underground stations. The ability and possibilities for formal and indirect social control relate to lower crime rates at the stations, pointed out in article 2, by for instance having a more open space and visibility from surrounding environment on the platforms. The defensible space concept herewith also provides anchor points on how to interfere in local spaces to make clear divisions between private and public spaces and how to increase visibility in a place so that social control can be exercised over the public space, decreasing opportunities for crime.

From an opportunistic perspective, the *rational choice theory* states that offenders willing to commit a crime assess the situation according to their risk and base their decision upon that (Clarke and Felson, 1993). In this evaluation the environment plays an important role as certain features of the environment may contribute to higher risks or lower risks of being seen and getting caught. One example is the presence of other people in the area; if it is a crowded place the offender will be less likely to commit a violent crime as many will witness the act and the offender may not be able to finish his action and get caught. On the other hand, a crowded place can be an opportunity for pick pocketing as this action will be hard to notice for other people around. A second example is the presence of hide and escape opportunities in the place. The offender will reconsider his actions if there is no place to hide or escape easily, which puts a higher risk on the crime opportunity.

Crime opportunities are created by knowledge and repetition. Differences in crime levels over time are linked to routine activities, as crime patterns tend to follow our rhythmic activities which are guided by time of the day, weekdays and seasons. Routine schedules provide an opportunity for crime, as they present regular repeated patterns and reoccurring opportunities (Cohen and Felson, 1979). Besides showing spatial concentrations of crime the first article demonstrates that crime concentrates in time as well. Most crime depend on this connection between space and time; as Cohen and Felson (1979) suggest, for a crime to happen there needs to be a motivated offender, suitable target and absence of guardians in the same place at the same time – the so-called *the routine activity theory*. A known

concentration of people (possible victims) in a small space creates the perfect opportunity to commit a crime. Such a location can be a transport node during rush hour. The reasoning lies in the influence of the context allowing for crime opportunities, which is indirectly guided by the daily routines of people. This theory relies on social patterns executed over a space, however in certain situations the environmental conditions are importance for crimes to happen. In order to understand the effect of the local environment on crime, theories such as *defensible space* and *broken-window theory* were used as the basis for analysis (see Table 1).

The *social disorganization theory* explains crimes from a social perspective (see Table 1). Variations in the spatial distribution of criminal offences can be linked to socio-economic aspects of the neighbourhood. The *social disorganization theory* relates crime activity to the social aspects in the neighbourhood and lack of social control (Shaw and McKay, 1942). The lack of or poorly executed social control generates crime. There is no closely related guardian to put the offender in the spotlights and execute punishment.

In relation to disadvantaged areas the *broken-window theory* points out the influence of physical incivilities on crime: it presents the clear connection between deterioration and increase of criminal activities (Wilson and Kelling, 1982). The suggestion is that a place in state of deterioration is a place that lacks control. Therefore, the place is assessed to raise fewer risks for the offender and increases opportunities for crime. The clear example is the broken window itself: if a residence with shattered windows is found in a neighbourhood and not restored, this can be taken as if none would like to take the responsibility to repair the windows and the neighbourhood has none who takes care or takes responsibility for its appearance and quality state. This can lead to more windows left broken and no one taking responsibility. Broken windows can turn into break ins, vandalism, burglary, and more violent crimes as the places appears to lack a state of control and thus risks to be apprehended for a crime seem to be low. Moreover, such areas with physical incivilities also create unsafe feelings and increase the fear of crime (LaGrange et al., 1992).

Environmental attributes have been argued to not solely be the contributor to crime levels. An integrated model for the explanation of crime in urban settings uses all socio-economic, demographic and environmental settings (Wikström, 1990). This model is based on the *routine activity theory* (Cohen and Felson, 1979) and the *social disorganization theory* (Shaw and McKay, 1942) but includes more of the urban environment; it uses the local land use aspects to explain variations of crime. According to Wikström (1990), local land use dictates what kind of activities and type of population can be found in a place. These activities (and population) vary over time and thereby influences the place its vulnerability to crime, as activities directly influence the number of interactions and criminal opportunities (Wikström, 1990).

A less pronounced aspect of crime and the effect of urban environments is the perception of safety. The feeling of being afraid to go around restricts citizens from using the available urban systems. This is most clear during darker hours of the day; night times are rather avoided, especially by women, when walking outside alone because of the fear of crime (Loukaitou-Sideris, 2006). It is therefore of importance not only to consider the physical aspects of the environment but also the social dimensions and affect the surrounding environment has on the perception of persons.

Crime in transport nodes

*"…this station is no different from the outside, what happens at the platform
in fact reflects just the conditions of the whole society outside…"*
A passenger using the green line

Transportation is the most important infrastructure for individuals to move around in a city. Having access to safe and secure infrastructure and transportation is a necessity for urban life. Safety at transport nodes is related to a variety of factors. The station itself and its environmental attributes are the first and most tangible level to examine and control. However, transportation is embedded within a city's infrastructure. Therefore also the surrounding environment and neighbourhood as well as the larger context of the city play a role. These provide a socio-economic and urban perspective, representing the station's relative situation in the city's organization.

Transport nodes are not necessarily the foci for more crime incidences than other places in the city (e.g. LaVigne, 1997). Nevertheless, several studies advocate that they are places where crime concentrates. Transport nodes are crime attractors and crime generators (Brantingham and Brantingham, 1993; 1995) since they concentrate large flows of people creating both a 'blend-in opportunity' for offenders and provision of several potential targets. Smith and Clarke (2000) argue that transport nodes are the places where the connection between environment and occurrence of crime is actually most apparent. Studies have continuously argued for the influence of surrounding environments. A couple of aspects in the vicinity of transport nodes affecting crime levels are for instance bars and alcohol shops (Block and Block, 1995), large infrastructures (Loukaitou-Sideris et al, 2002), commercial and entertainment centers (Kinney et al, 2008), youth hang-outs, parks, and schools (Newton and Bowers, 2007), and many more. For transport nodes, land-uses and social activities play a large role in influencing crime levels. The socio-economic situation of the neighbourhood is linked to crime levels at the station. It is proven that deprived areas with more crime have also stations with higher levels of crime (Pearlstein and Wachs, 1982). Often transport nodes are not a stand-alone feature in the urban space, but part of a larger structure and urban fabric. Commonly, they are surrounded by some forms of commercial activities and other mixed types of land-uses. In article 2 of this thesis, the surrounding

environment proved to be explaining crime levels at the stations; e.g. population density, housing mobility, location of cash machines, and location in the city.

Safety and planning

> *"Urban planning requires an understanding not only of the physical space where we live, but also underlying social, cultural, political, and economic landscapes"* (Maantray, 2010, p9).

Crime prevention practices make use of principles of the previously discussed theories to decrease crime opportunities and reduce incentives for crime. The *defensible space theory* by Newman (1972) stands on the basics of the *'crime prevention through environmental design'* (CPTED) concept. CPTED makes use of the principles of visibility and control and suggests a set of strategic environmental interventions in space which can decrease opportunities for offenders and bring the feeling of control of own environment back to the original users (Newman, 1992). The implementations in the urban environment are to dissuade offenders from committing crimes in that specific place. CPTED is linked to the local environment, as it suggested interventions aim at decreasing crime at the micro level, such as buildings, stations, and streets (see Table 1).

The concept applies several implementation areas, of which surveillance, access control and territoriality are the strongest (Figure 1). The first two aim at limiting crime opportunities by adjusting the urban environment, the latter focuses on reinforcement of places by social control. A couple of examples given by CPTED to improve natural surveillance are increase of pedestrian traffic, placement of windows to allow informal surveillance, place lighting along paths and pedestrian areas and light up known problem areas, placement of CCTVs, and increase of social activities. For access control measurements have been suggested as using (landscape) designing to provide defined points of entry and exit, use gates and regulated access, control flows, implementing barriers in form of bushes, low fences, demarcations, and eliminate design features that allow access to roofs. Territoriality can be improved by increasing the sense of ownership and control, put up signage that security measures are in place, keep the place clean and avoid strong target hardening, like spikes and barbed wire, which suggests a lack of real-time on-site control (Newman, 1992; Cozens et al., 2005).
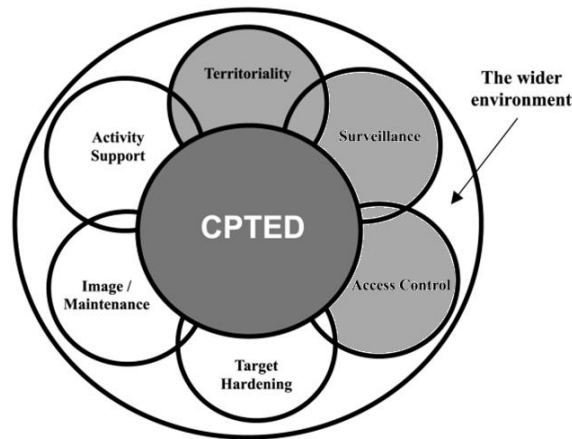
Figure 1 – The different areas of intervention by crime prevention through environmental design.
Source: Moffat (1983, p.23).

At underground stations many of the CPTED principles can be applied, by adjusting them to the stations' lay-out and environmental preconditions. Therefore, the basic principles of improved surveillance, controlled access, maintenance, target hardening and creation of territoriality remain relevant. It can be appropriate to install good lighting, in particularly for problem areas as dark spots. Put signs in place of control and consequences for violation of rules. A more directly effective crime prevention strategy would be to increase control via guards, cameras and presence of informal guardians. Limit the ways of entry and exit. Create a clean, nice atmosphere enhancing the feeling of responsibility. Providing excellent overview and view from outside to all places of the station as well as from the station towards its surroundings increases visibility and surveillance opportunities.

CPTED applications have proven to be effective in reducing crime by applying ideas of environmental design (Cozens et al., 2005). Grönlund (2012) presented the case of a newly developed neighbourhood in Stockholm which partly follows CPTED principles, although not consciously taken as a primary principle in the planning decisions. Findings show that the neighbourhood had good private-public demarcations and semi-private areas allowing social control, provided good aspects of surveillance from shops, windows, residences and good overviews of public spaces. Moreover, the area was easily accessible, showed good traffic flows, applied robust designs, and provided space for activities. In numbers the neighbourhood proved to have lower crime rates and higher feelings of safety of residents than other comparable areas in Stockholm.

In summary, the theories discussed in this section have been used in this study as a background to elaborate hypotheses to be tested, discuss results on the variations of crime over time and space and the relation to the environments of underground stations and their surroundings. The thesis illustrates the application of these theories while proving the connection to crime and suggesting a more integrated framework when it comes to prevention of criminal acts.

1.3 Methodology

How can one identify crime patterns and how can they be analysed? Crime is a typical event which has much geographical information attached to it. Crimes seldom occur as an isolated event. On the contrary, an offence happens at a certain place and at a certain time. Moreover, a victim, an offender, duration in time, and aspects of the surrounding environment are connected to an unique event. These data linked to a crime event are highly valuable for crime analyses.

The uniqueness of crime data is their location information. The event happened at a certain place and has thereby often a recorded coordinate or street address, which can easily be geocoded and mapped in GIS. Geocoding is an important part of crime mapping and analysing as it creates the basis for identifying patterns and clusters. Geocoding means to connect the location of an event, as included in a crime record for instance the street address, to a coordinate in GIS-software so that the event can be shown visually on a map with a standardized reference coordinate system. Automatic geocoding helps, however not every single event corresponds with the coordinate or reference system, so there is a need to look more detailed and perhaps manually geocode part of the cases.

Spatial analysis aims to identify and explain these patterns in geographical data (Ackerman and Murray, 2004). Spatial analysis techniques such as Geographical Information Systems (GIS) helped to visualize and identify crime concentrations, hotspots, and to put the numbers and often vague figures on the map. Maps have the power to show an instantly recognizable picture; in the case of crime a situation to be tackled. Mapping can be helpful to deduce aspects of crime patterns related to underlying processes (Hirschfield and Bowers, 2001). Statistical analytical tools, as SPSS software, make it possible to apply statistical techniques in order to assess and investigate relations and interactions between crime rates and the urban environment. Hirschfield and Bowers (2001) moreover argue that for crime prevention to be successful, specific analyses of crime data is needed to aid to the needs requested for individual prevention strategies and different organizations dealing with crime prevention.

The analysis of crime may include the analysis of spatial patterns (e.g. Almeida et al., 2003), temporal patterns (e.g., Långström, 2002), combinations of these (e.g. Nelson et al., 2001), relations to the environment (e.g. Perkins et al, 1993), relations to victim and offender (e.g. Block, 1981), and many more. Linking crime data to area based addresses and socio-economic information helps both the creation of maps and modelling of the data (Haining, 2012). The thesis applies several different techniques for analysing patterns of crime (see Table 2). Spatial analyses consist of the use of GIS techniques combined with cluster detection, the latter is the main technique used in the first article. Modelling makes use of the crime statistics and employs statistical techniques like regression analysis to identify relationships of crime and the environment, as explored and applied in the second and third article. This thesis uses data on crime events, retrieved from police records (Stockholm Police Headquarters).

Table 2 –Analysis methods and articles in the thesis.

	Article 1	Article 2	Article 3
Cluster Detection	●		
GIS, Mapping & Spatial analysis	●	●	●
Statistical modelling		●	●

In order to be able to use crime data in a geographical analysis, it should be recognized that these events are originally point data and therewith represent a single point in space and in time. Point data is easily analysed through different software and techniques, however it requires long computing times, in particularly when a whole crime set of several years is being used providing thousands of individual events. Therefore, often crime data is aggregated to a particular level, as for instance, regions, neighbourhoods, or administrative areas, resulting in polygon based information. The aggregation helps also the ecological analysis with demographic and socio-economic indicators of the population at risk.

In urban criminology researchers have explored and applied many techniques. Ecological analysis is commonly applied, as well in this thesis, to assess relationships and causalities between crime and socio-economic and demographic data of the environment (Ackerman and Muray, 2004). Current applications of spatial analysis include 'space-syntax' methods to examine spatial patterns, three-dimensional modelling to assess impacts of and on crime, spatial regression models, spatial clustering, and virtual simulations and participation models (Ceccato, 2012).

Statistical techniques in detecting crime concentrations

Spatial analyses include simple variants as mapping and visualizing patterns (space/time) and more complex techniques, such as hypotheses testing and modelling. Concentrations of crime consist of a collection of crime events found in the same limited area. Space-time clusters moreover, take notice of the time dimension and identify space-time concentrations by a collection of events in the same limited area and within the same limited time span. This thesis uses mainly aggregated crime data on the base of local administrative units (in Swedish, *basområde*).

Just a visual interpretation of crime distribution on a map may lead to an erroneous analysis of concentration. A common way to go is to create crime rates of administrative areas based on their population (depending on crime type). The choice of the denominator has been an eternal point of discussion among criminologists and the like. This analysis bases crime concentrations on the risk of exposure of the population in an area and identifies crime patterns accordingly. The population at risk in this thesis applies to population in administrative units (article 1) and passengers using the underground stations (articles 2 and 3). The latter were estimates based on counts of passengers registered over a day by the

Stockholm Public Transport Agency (SL), of people passing the gates, both going in and out, at each station. In Stockholm, for instance, the central station has the most recorded crime events, however, when the population flow is taken into account the central station ranks somewhere in the middle as of course it concentrates high numbers of people and thus high risks (and opportunities) for crime.

Various techniques have been used to identify concentrations of crime events: contour mapping, k-mean clustering, kernel density smoothing, standard deviation ellipses, repeat address mapping, among others (for a comprehensive review, see Goldsmith et al., 2000). The identification of hotspots is argued to be one of the most important assessments in spatial crime analysis (Ratcliffe and McCullagh, 1999). Evidence indicates that targeting of identified hotspots by policies and prevention actions noticeably decrease crime in these places, often called hotspots of crime (Kennedy et al., 1997; Weisburd and Green, 1995; Sherman and Weisburd, 1995). A hotspot is a pattern of crime occurring in a relatively small space, based on that the recorded number is higher than the excepted number of events and the number of events concentrates highly in a short time period (Canter, 2000). Specific spatial statistical analyses applied for crime concentrations are global and local indicators of spatial association (LISA), as global (Morans I) and local (Getis Ord) autocorrelation (Ratcliffe and McCullagh, 1999).

Recently, focus in urban criminology has shifted towards finding space-time patterns in crime concentrations. Most studies have so far only focused on identifying spatial patterns of crime, but with the nowadays available data much more can be extracted. According to Ceccato (2008), these new types of analysis make that crime research becomes much more actual, interactive and dynamic. Space-time analysis makes use of both the information about the place and the time and identifies patterns based upon both these aspects. In the first article on space-time clusters, a specific tool of analysis is introduced: the Kulldorff's scan test. This tool makes it possible to identify concentrations of crime and detect hotspots of crime from input data based on a geocoded database.

With the detailed databases created in GIS, there was the possibility to apply a cluster analysis on the crime distribution over Stockholm's demographics. The Kulldorff's scan test[3] is an outstanding tool for analysis of concentration of events. It has the advantage of being able to detect concentration in both space and time. The software provides many types of analysis for cluster detection, ranging from only spatial analysis to combined spatial-temporal analysis. The Kulldorff's scan test was chosen because it bases the cluster analyses on user input which should consist of point data, such as crime events. The detection analysis can be based upon several models and depends on the data available for input. In the case of this study the input data are the crime events, which is a discrete data type, and the socio-economic background values, which consist, among others, of population numbers.

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[3] SaTScan version 9.01 (Kulldorff, 2010). Available for free download at http://www.satscan.org/.

Therefore the appropriate models to be used are the Poisson and Bernoulli models. The Poisson model scans for clusters based upon the underlying population at risk (here the population in the district), while the Bernoulli model calculates clusters upon a set of case variables and a counter set of control variables, which here represents for instance, crimes happing during the day countered by crimes happening during the night. As for urban crime this thesis applies the idea of population at risk, to analyse concentrations of crime, the Poisson model fits perfectly as a model. The space-time cluster detection uses a method which bases the concentrations on a fixed window that moves in space and time so that it visits each possible location and each possible time. This procedure results in an infinite number of clusters, overlapping each other, which each represent a possible cluster. The primary and secondary clusters are identified by concentrating the highest risk in time and space.

Modelling of the crime rates and relation to environments at the stations and surrounding areas in article 2 and 3 was done in multiple stages. Modelling is common practice in exploring influences and causal relationships. The modelling used in this thesis is based on ordinary least square (OLS) regression, analyses of variance and correlations between the environmental attributes and crime rates.

The environmental attributes were collected by means of field study. All the stations on the Stockholm underground system had been visited and 'inspected' according to a check list. The check list consisted of a list of design features, attributes, and environmental situations. Among others, the lay-out of a station was checked for such as dark corners and illumination, the overall atmosphere was assessed, the visibility at the station and visibility of cameras and other security measures. Most of the features were assessed using a binary scale, using yes or no possibilities. A couple of features were listed according to a range of high, medium, low, as for instance surveillance opportunities. These lists have been the input for the modelling of the influence of environmental aspects on crime rates.

As regression analyses are based on the assumption of independence of explanatory variables, a correlation analysis was used to identify if certain attributes are related to each other (when high correlation is found, one of the variables is excluded from the model). Another OLS assumption is that the residuals have constant variance (non-heteroskedasticity). The errors are normally distributed; not showing signs of spatial auto-correlation on residuals. OLS regression assumes that the independent data is normally distributed; in case of a skewed distribution, a transformation of the dependent variable is suggested. This can be done, for instance, by applying a natural log function to the values, as done for the rates in this thesis.

1.4 The study area

The city of Stockholm is home to 877,543 inhabitants and is the capital city of Sweden (SCB, 2012). Stockholm is mainly built upon several small islands, covering 216 square meters (including water) and located next to its wide archipelago. The urban areas are very well connected by infrastructure and green areas reach all the way in to the centre. The main public transportation is the underground system which is composed of 100 stations, which share three lines (green, red and blue), transporting around 1,800,000 passengers daily. The main transport node is located in the city centre; all lines pass through this central station (T-Centralen) (Figure 2). The main city core is the central business district where most offices, shopping and entertainment activities are located. The suburbs of Stockholm are of varying nature. In the north and east there are affluent neighbourhoods with mainly villa housing. In the south and northeast, multiple family housing and low-income groups dominate. Most high income groups reside in the city centre or low density suburbs adjacent to the centre.
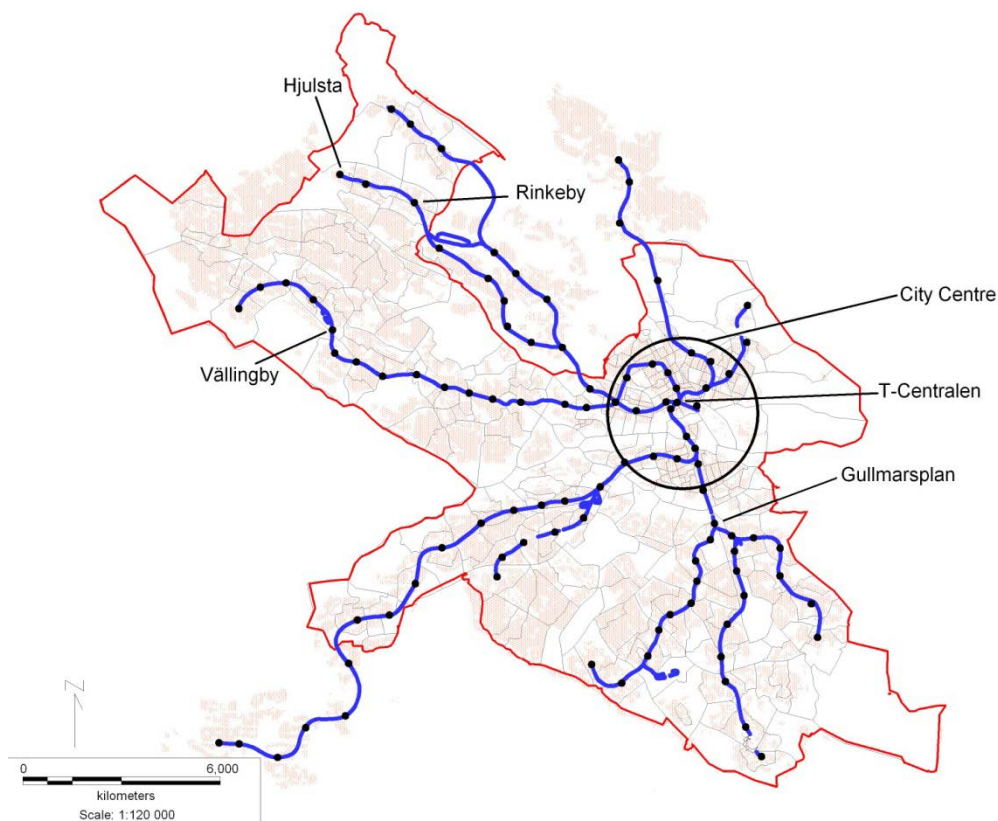

Figure 2 - Map of Stockholm City. Highlighted in red: Municipal border (study area), black: city centre location and underground stations, blue: underground lines.

Previous studies on Stockholm's urban crime

Previous studies have pointed out concentrations of crime in the centre of Stockholm, in problematic suburbs and regional centers (Wikström, 1991; Dolmén, 2002; Ceccato et al., 2002), other studies relate crime to high discount of housing prices (Ceccato and Wilhelmsson, 2011). Little is known however about the current city criminogenic conditions and how they relate to safety in transport nodes.

Wikström and Dolmén (1990) presented an ecology based analysis of crime trends in different urban environments in Stockholm. They showed that street crimes and vandalism where more common in the inner-city. Crimes against persons and car-related thefts had the highest rates in the centre. The outer city areas showed higher rates of violent crimes as well as the highest rate for residing offenders (Wikström and Dolmén, 1990). The trend analysis showed that the inner-city area had a far higher increase in crimes than the outer suburbs; this was in particularly visible for personal crimes and vandalism. Residential burglary was high in affluent outer suburb areas, and surprisingly in lower social status areas in the outer spheres. The effects on crime incidences were mainly explained by neighbourhood variables as family residences, social problems, socio-economic status and working places (Wikström, 1991).

Dolmén (2002) added to the field of Swedish criminology by analysing differences of crime in between local areas in Stockholm, based the assumptions of routine activity and disorganization theories. Dolmén found similar patterns of crime concentrations in the city centre, problem suburbs and larger regional commercial centers as did Wikström (1991). A striking conclusion is the confirmation of concentrations of outdoor violence in the centre and indoor violence in the suburbs. Neighbourhood variables contributing most to violent crimes were confirmed to be social problems and working places, while for burglary the type of family housing was more significant. Dolmén (2002) highlights the fact that a significantly large part of all vandalism cases is reported at and around public transportation. Moreover, he shows the concentration of crime in time; overall crimes count more incidences in the afternoon, between 13-16pm while during the evening and night levels are clearly lower. Furthermore, different types of crime were also identified to be concentrated at different times. It was observed that violent crimes are dominating evening hours and property crimes dominate day-time hours (Dolmén, 2002). This can be linked to routine activities for both, where the first creates opportunities for crime in terms of meetings between offender and victim and the second creates opportunities by omitting these terms. Although not as concentrated as hourly crime reports, also during weekends higher levels of crime occurred as compared to weekdays (Dolmén, 2002). By taking crime types separately a two way concentration unfolds of higher levels, being mainly property crimes during day time on weekdays and violent crimes during evening and nights on weekends (Dolmén, 2002).The latter suggest the concentration of crime in the city centre and its relation to the concentration of pubs and entertainment facilities found there.

Changes in the crime trends of Stockholm were analysed by Ceccato et al. (2002), by taking Wikström's findings from the 80s and comparing the spatial distributions with the crime distributions of late 90s. In fact, distributions of crime offences did not show much difference between 1980 and 1990. For vandalism concentration can still be found in the inner city, however, the pattern was more spread out, extending to the suburbs. Ceccato et al. (2002) show signs of similar evidence. Theft from cars has emerged in a couple of new areas besides the inner city; high levels of theft appeared also in southern Stockholm. Burglaries continue to show a very scattered pattern, and neither present a clear conclusion ten years on; some places have increased risks (problem areas) while others have lowered their levels (affluent areas). Crime rates were found to be explained mainly by socio-economic contexts and the lack of stability (in 'problem' areas) and guardianship (affluent areas) (Ceccato et al., 2002).

None of these previous studies deal with the combination of crime patterns over time and space. The first article of the thesis uses Kulldorff's scan test to explore the detection of crime hot spots in 2006-2009. The article identifies the concentration of crime clusters with a focus on different time spans, showing shifts of crime in space-time patterns within a year, week and day. The results connect to transportation systems and urban fabric; and the neighbourhoods' characteristics.

1.5 The main contribution of the thesis

The articles in this thesis have focused on different aspects of the relationship between crime and urban environments. The contribution exist from explorative analysis of urban crime, to explaining variations in crime levels and the influence of the environment, to suggestions on how to prevent crime and improve the environmental situations at underground stations. These topics can be divided in specific research fields (Table 3):

Table 3 – Research topics of the thesis.

	Article 1	Article 2	Article 3
Urban crime & Patterns	•		
Explaining crime & Environment		•	•
Urban planning & Policy			•

Article 1 - 'Space-time clusters of crime in Stockholm, Sweden'

The first article contributes to the research field of patterns of urban crime. GIS was used for spatial analysis, while at the same time the article with satisfaction applied a new tool for cluster detecting of data. Although often used in epidemiology studies (e.g. Gaudart et al., 2006; Chen et al., 2008; Elias et al., 2006) the Kulldorff's scan test is not commonly used in criminology studies. Moreover, findings provide strong evidence of a Scandinavian city which has not yet been found in the literature.

The article seeks to detect clusters of crime in Stockholm municipality while at the same time exploring digital tools for crime cluster analysis. The article identifies several crime concentrations over the day, week and seasons. The results point out that crime concentrates in the centre, problem suburbs, larger regional centers and around transport nodes. Results of crime rates show that property crimes are most concentrated in the afternoon at day-time, while violent crimes concentrate in the night. These findings confirm those found in previous studies in the 1980s and 1990s in Stockholm. Likewise previous studies showed Stockholm city centre is a hotspot of crime (Wikström, 1991; Dolmén, 2002; Ceccato et al., 2002) regardless time of the day and type of crime. Weekends are more prone to crime, and similarly seasonal variety shows clear patterns which follow our scheduled activities. In the winter especially crimes are more concentrated around transport nodes and during the summer more spread out over the municipality.

Violent crimes concentrate in the city centre, around places of entertainment, and can be found in some of the suburbs. These suburbs cope with social problems and are sensitive to crime because of underlying socio-economical aspects. The influence of social problems and economic status on crime levels has been conceptualized in the social disorganization theory (Shaw and McKay, 1942). The theory states that in principle, a neighbourhood suffering from social problems also lacks the power to exercise formal and informal social control. The lack of social control in these areas makes them to indirectly allow criminal activities and put no hold to actions of offenders residing there, on the contrary they may even feel encouraged to do so. These areas are typically identified with neighbourhood compositions like low income, high percentage of foreign background, immigrant population, low socio-economic status, high ethnic heterogeneity and high migration patterns creating an unstable housing market (Shaw & McKay, 1942). As the first article suggests, crime clusters in Stockholm follow a pattern related to the city's central activities and suburban problems. It is of high importance to notice that crime is not stable over time but shows different distributions at different times in different places. Crime prevention and police intervention should put their resources on the hotspots pointed out at each different time span. As an example, specific places of crime concentration, no matter time or day, are Vällingby centre, around Gullmarsplan (a large transition node), the city centre, and Rinkeby, Hjulsta (for an geographical indication see Figure 2). However, during evenings, weekends and winters actions should focus on the city centre and transport nodes.

Article 2 – 'Security in Stockholm's underground stations: the importance of environmental attributes and context'

The second article assesses the impact of the environment on crime at underground stations by using GIS and statistical techniques. The current international literature provided strength and value for interpretation of this Scandinavian case study. Furthermore, results

on variations of crime at transport nodes in space and time add to the thin evidence in present literature on space-time variations of urban crime and in transport nodes.

This article acknowledges the different surrounding environments (neighbourhood characteristics) and uses routine activity principles and urban criminological theories to show the diverse influence of different environments. The results show that over half of all offences in Stockholm municipality occur within a 500 meter distance of underground stations, concentrating in just under one-third of Stockholm's area. It was found that these surrounding environments consist of diverse land use patterns which often facilitate several well-known crime attracting facilities, such as pubs, restaurants, banks, alcohol selling shops (Brantingham and Brantingham, 1995). The nature of these offences is not the same for every station at all times. The local environment at a station, in relation to its surroundings and resident population defines a large part of the difference in crime levels at different stations. It represents similarities with what Wikström suggested as crime influencing links in his conceptual model (1990). In general, the major part of registered offences is events of public disorder (e.g. drunken people), followed by fights and vandalism. Some stations report higher levels of violent crimes (fights and violence occur often at for instance, Hjulsta and Vällingby), while others show higher levels of property crimes (thefts are common at T-Centralen). As article 1 already indicated, different types of crime concentrate at specific times and at certain transport nodes. At and around the underground stations theft happens mostly in the afternoon, vandalism in the evening and violence in the night. Although the most events had been reported at the central station and bigger stations of Stockholm, the risk of crime (occurrence per thousand passengers a day) was found to be higher at peripheral stations, end-stations, and stations located within hotspots of violence and property crime. These results suggest strong links to findings in the first article, the influence of surroundings and social disorganization theory.

Figure 3 – Examples of (a) littering at an underground station and (b) dark, hidden places at underground stations. Copyright: Author.

Upon further inspection, the environmental attributes at the stations could often explain half of the variance of the crime rates between stations. Variables that were associated with higher crime rates are: low surveillance in terms of few people being around, low visibility, many corners and hiding places, bad illumination and the presence of littering and social disturbance (Figure 3). By adding the neighbourhood aspects of the stations' surroundings, it was found that crime rates increase at more peripheral stations, in sparsely populated areas, neighbourhoods with physical deterioration, and more cash machines but fewer police stations in the surroundings. However, the significance of these variables can vary by crime type. The conclusions point out that there is evidence for the link between environmental attributes and crime levels at transport nodes, an effect of both the stations attributes and their surroundings. Adding to that, specific stations see different patterns of crime and need a particular intervention approach. No general crime prevention approach should be applied, but rather a focus of specific targeting of particular stations at particular times, using a whole journey approach including the surroundings.

Article 3 – 'Making transport nodes safer: an agenda for actions in underground stations in Stockholm, Sweden'

The third article contributes to the research field of urban crime and crime prevention by suggesting a detailed agenda of interventions. The article provides suggestions for the police, local crime prevention councils, organizations dealing with safety issues, municipalities, county councils, transport organizations, etc., to deal with crime problems at transport nodes.

Based on the findings of significant environmental attributes affecting crime rates, interventions should take up a whole journey approach focusing both on the stations and surroundings. This means that the intervention reaches over different areas, several authorities involved and requires a better coordination between transportation agencies and other authorities. Environmental design interventions can help eliminate some of the stations' crime attracting features, nevertheless this should be complemented with policing and neighbourhood watch schemes, general information campaigns and increased usage of security technologies.

Figure 4 – Examples of (a) a light clean underground station and (b) CCTV installed at the entrance of an underground station. Copyright: Author.

Suggested actions to improve safety at the underground stations in Stockholm include the identification of those stations in need of intervention. Nowadays, resources can be wasted by placing them in the wrong place at the wrong time. Interventions should focus on the worst places first, and these places are in need of more detailed monitoring. Secondly, it is important to locate and reduce features of the stations that influence visibility negatively and to improve surveillance possibility at the underground station and surrounding. As is promoted in the crime prevention through environmental design (CPTED) concept, the enhancement of environmental features deterring crime opportunities can have a strong impact (Figure 4). Features such as dark spaces, benches, many exits and escape routes have an attraction on offenders (Loukaitou-Sideris et al., 2002; Piza and Kennedy, 2003) while features as lights, cameras, signs scare offenders off (Loukaitou-Sideris et al., 2002; Harris, 1971; Webb and Laycock, 1992; Morgan and Smith, 2006). Thirdly, signs of deterioration and lack of control should be eliminated and the pleasantness of the stations improved for higher feeling of security. Furthermore, intervention schemes should adapt local initiatives and safety suggestions from the local community and focus on the needs of individuals. Lastly, promoting gender safety and equity principles needs to be placed higher on the agenda to be able to provide equal access to public transportation for all citizens.

1.6 Limitations

There are a number of limitations in this study that are worth noting. The first one is related to the procedures involved in the fieldwork. The check list was tested in a pilot field work but was not error proof. Some new indicators were added along the fieldwork process. This has led to some missing data, and revisits, costing time and money. As the field work was carried out mainly by two persons, it was coordinated to avoid large discrepancies in recording the observations. Yet, it cannot be disregarded that observations from time to time

are subjective to the researchers' own perception of space and feeling. This limitation is common among all case studies applying observations, not the least in the field of urban planning. One way to decrease the discrepancies in data collection is to use only one observant, or do more observations so that the differences can be outweighed by the amount of data. In this study, the results of the observed data proved to be similar (by double checks after the fieldwork) and did not show major differences between observations.

The Kulldorff scan tests have provided satisfying results in using crime data and showing concentrations of crime in Stockholm, although at the aggregated level. The first tests with point data from all the crime cases proved to be too time consuming and detailed for this analysis. Time and efficiency are two aspects limiting research results. Moreover, when testing different population bases for space-time scans, the result showed to be slightly different. It can be concluded that the provided population base for the scan test is of outmost importance for the results. In this thesis the different populations have been used according to time of the day (day time and night time populations). If only day time population was used, the results would show a night time setting pointing towards residential areas where at those times no one resides and thus the population base is lower.

The modelling chosen in this thesis has been an OLS based analysis, under the assumption that it was favoured to compare the crime rates to the environmental attributes. Modelling has been done manually with different sets and different models. A step-wise regression was never fully performed, as the least contributing attributes had been taken out manually or kept because of their importance in previous studies. Analysis of the variations between variables at a station can be applied too, in order to check for differences at each station. This would suggest a more detailed modelling and needs more time than carried out in this thesis.

Crime police records are not problem-free. The dataset was acquired by special permission and received as provided, with some missing data (such as coordinates; from the original 649 146 police records 9406 lacked any coordinates, of the total records around 80 per cent could be geocoded due to lack of data on coordinates, exact place, or double entry). In order to try to avoid these limitations, four years data was collapsed into one. If a hotspot is identified using a four year aggregated data set it means it is a steady and stable problem and needs attention. Another limitation in identifying hotspots of crime distributions over space and time is the uncertainty of the crime records. Often the victim does not remember exactly when and where the offence happened. Starting time and place blur out over the whole event and the duration of the event can often not be recalled correctly. It is therefore important, as a researcher, to check the data and adjust for missing attributes by for instance combining times, such as aggregating starting and finishing times done in this thesis.

Often when crime and safety problems are reported in media the figures shown, present the crude number of events. As pointed out in this thesis, this can give a distorted picture of

reality, and may increase wrongly interpreted assumptions which make interventions and policies fail. One should have in mind though, that also rates are not free of problems. As in this thesis crime rates are based upon population, some places may show high rates of crime because the population base is low. For instance, if an area has 250 crime cases and only 5000 population, the rate is 50 per 1000 population. An area with the same crime levels and half the population will show a risk of 100 per 1000 population. On the other hand, an area could show much lower crimes numbers like 25 but also show a much lower population base of for instance 500, resulting in the same crime rate as the first example. Using rates therefore requires checking the data and interpreting accordingly.

1.7 Summing up and reflections

The aim of the thesis was to analyse crime patterns and the effect of physical and social environments at transport nodes. For the analysis of crime patterns GIS techniques and cluster detection have been applied to locate crime concentrations. Statistical analysis was performed to find relationships between crime levels and the environment. Mapping proved to be one of the main tools to present results and assess spatial distributions. Statistical modelling was only possible after the inspection of environmental attributes through field work of all underground stations.

Findings are in line with other studies on urban crime: also in Stockholm crime concentrates in specific areas and shows varying patterns over time. Article 1 identified these space-time variations in Stockholm and found that clustering of violent and property crimes show different hotspots at different times. Crime patterns tend to follow people's scheduled patterns, and the results affirm a strong relation to routine activity theories and crime in Stockholm. Crime opportunities arise at places where people meet and converge, in Stockholm hotspots are located in the city centre, regional centres, transport nodes, and problem suburbs. The latter relates to social disorganisation theory, linking internal social problems to increased crime rates in the neighbourhood and public areas. Linked to this are the results from article 2, also at underground stations located in the periphery of Stockholm and in problem suburbs crime rates are higher; two-thirds of stations with the highest rates is located within one of the identified hotspots of crime. The socio-economic composition of the surrounding tends to have a significant influence on crime at transport nodes. Article 2 identified the more peripheral locations, low guardianship and visibility, surrounded mixed land-uses, population density and housing mobility as inducing higher crime rates at the stations. Therefore article 3 suggests that crime prevention policies should focus not only on finding crimes and taking them out of the place, which may just relocate the problem elsewhere, but rather follow a holistic approach with a focus on the whole environment and socio-economic aspects of the surroundings of the place.

Yet, a place does not become better if one does not feel safe. The feeling of safety is an important aspect of urban crime and safety, which has not been addressed much in this thesis. Therefore, a short note on this is pointed out here. Presented in article 2, a survey in Stockholm showed that passengers were more afraid on the way to and from the stations than at the stations itself. The feeling of safety does not imply that also crime levels in the area are high, though this is often the case (see Loukaitou-Sideris et al., 2002). A sustainable city depends on the perception of a place. If one does not feel any attachment to an area, he or she may not want to interfere or feel responsible for what is happening there. If other individuals feel in the same way, poor social control of the area may lead to crime. Further studies should examine closer the relations between the actual crime levels and perception of safety in a place. This applies to the nowadays debate on gender issues and safety. It has been shown before that women perceive public places and transport nodes as more fearful than man (Loukaitou-Sideris and Fink, 2009).

Variations of crime over time have been acknowledged throughout the thesis. Crime events concentrate in the later hours of the day, during weekends and holidays. In order to provide insights for crime prevention, future studies should consider looking more detailed at the links between environment and crimes at specific times. Can it be stated that crime levels are affected by the environment in the same way over the cause of a day, or are there differences between 2am and 2pm, day and night, weekdays and holidays, winter and summer? An analysis on the different effects of the environment at different times should provide more detailed data on how to deter crime and where to target resources for crime prevention.

Findings from article 1 and 2 provided useful focal points for delineating suggestions for crime prevention in transport nodes. In the future, the analysis can be expanded to include more of the physical environment and included physical barriers, land-uses, and other geographical aspects. The link between surroundings and crime perception needs to be better understood. In this research the crime events had been allocated a particular station or neighbourhood, because no more detailed data on the exact place was available. However, it would be very useful to be able to receive data and link it to specific parts of the station as entry or platform for instance and places in the surrounding area.

The design of a transport node proved to be of high significance to explain crime variations at underground stations in Stockholm. Article 2 found that environmental attributes influence crime rates at the underground stations. Evidence is provided for a strong relation between higher crime rates and signs of deterioration, lack of control and a need to improve visibility and surveillance possibilities. Specific design features that need attention when constructing or redesigning underground stations are illumination, corners, passenger flows, and feeling of pleasantness. Moreover, social factors as reducing incentives for littering and disturbance should be considered, for instance by setting up clear rules and consequences for violations. The results of this thesis suggest points of crime intervention and crime patterns that can directly influence prevention strategies of responsible authorities. As pointed out by

Hirschfield and Bowers (2001), the use of crime analysis for supporting decisions in crime prevention strategies is of high importance for organisations involved. Police instances get a very detailed picture of where and when exactly crime occurs. With this information prevention strategies and security patrols can be directed to the identified places at specific times. At first policies should be based upon a 'whole journey approach', in other words: from door to door. Furthermore, it is of importance to not waste resources and therefore identify those stations in need of immediate intervention. Of high importance at transport nodes and their surrounding is the focus on improvement of visibility and natural surveillance. Moreover, signs that 'nobody is in control' should be eliminated and pleasantness at stations enhanced. Additionally, safety initiatives should be adapted to particular needs of communities and groups of individual, and thereby promoting gender and equality issues in public transportation.

It can be discussed how these intervention may affect crime levels elsewhere. Not being part of this thesis, an empirical question for future research can be to investigate if crime events are only displaced or if a significant decrease be observed. The impact of interventions on the offenders' perception of the space is a discussion per se. According to rational choice theory for instance, offenders assess the situation according to their own risk. It can be argued therefore that, for instance, if stations will be improved towards deterring crime, offenders will find other places to commit their crimes. On the other hand, offenders are very creative and can also adjust to new situations by inventing new offending techniques avoiding the newly implemented interventions. Implementing a 'whole journey approach' for crime interventions may deal with crime displacement there the wider area, such as neighbourhoods, is taken into consideration.

This study shows clear links between safety and urban environment, which is relevant for intervention and urban planning. However, there is more to be done. Future studies should consider closer examination of differences of crime over time, the relation to the surrounding environment, the influence of fear of crime and relation to the environment, the links between population, offenders and high crime places at transport nodes but also on the perceptions of different groups of society, not the least women, the elderly and other groups that often declare to feel more fearful than other groups in society.

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Chapter 2 - Articles

Article 1 - Uittenbogaard, A.C., and Ceccato, V. (2012). Space-Time Clusters of crime in Stockholm, Sweden. *Review of European Studies*, Vol. 4 (5), p.148-156. (*doi*: 10.5539/res.v4n5p148)

Article 2 - Ceccato, V., Uittenbogaard, A.C., and Bamzar, R. (2011). Safety in Stockholm's underground stations: the importance of environmental attributes and context. *Security Journal. (doi:* 10.1057/sj.2011.32)

Article 3 - Uittenbogaard, A.C., and Ceccato, V. (ff). Making transport nodes safer: an agenda for action in underground stations in Stockholm. *European Journal on Criminal Policy and Research,* submitted.