

DO SPORTS STADIUMS GENERATE CRIME WHEN THEY ARE CLOSED?
A NATURAL EXPERIMENT ON THE DELAYED EXPLOITATION OF CRIMINAL
OPPORTUNITIES

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ABSTRACT

Crime pattern theory claims that busy places generate crime through immediate and delayed exploitation. In delayed exploitation, offenders notice criminal opportunities during opening hours but return to exploit them later. This study investigates delayed exploitation by testing whether soccer stadiums locally increase police recorded property crime on non-game days. A soccer stadium closure created a natural experiment. We estimate linear regression difference-in-difference models to compare crime rates on non-game days around the stadium, before and after the closure. The closure reduced non-game day property crime beyond the citywide property crime drop. We conclude that criminogenic effects of busy places extend beyond their opening hours, confirming the delayed exploitation mechanism, and that crime prevention strategies should also target these places outside opening hours.

KEYWORDS

Crime pattern theory; crime generators; property crime; crime hot spot; soccer stadium

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INTRODUCTION

Crime is neither equally nor randomly distributed in space (Sherman et al., 1989, Weisburd, 2015). Some places experience more criminal events than others and become hot spots of crime. Crime pattern theory offers a comprehensive explanation for the spatial clustering of crime. Within crime pattern theory high-crime places are referred to as crime generators (Brantingham and Brantingham, 1995). Crime generators are ‘busy’ places or facilities that fulfill pivotal roles in the lives of many.

Focusing on a large soccer stadium, a crime generator with discrete opening and closing hours, we test one of crime pattern theory’s hitherto untested propositions that crime generators exhibit a *delayed criminogenic effect*. Our main hypothesis is that whereas a soccer stadium is open to the public and attracts large volumes of people episodically—on average a few hours every fortnight—it persistently raises crime levels in the surrounding area at times when the stadium is closed. Confirmation of the hypothesis would support the existence of a delayed criminogenic effect, help explain some anomalous findings in the recent literature on the lack of spatiotemporal variation in the criminogenic effects of certain places, and have practical implications for formal and informal guardianship around crime generators outside opening hours.

The crime-generating effect of crime generators has primarily been attributed to their bringing together in space and time large concentrations of motivated offenders and suitable targets (Brantingham and Brantingham, 1995). This implies that the criminogenic effects of crime generators may be limited to their opening hours and tied to temporary visitor flows. However, these places may continue to generate crime at times that they are not open, through the delayed exploitation of previously encountered criminal opportunities (see Brantingham and Brantingham, 2003, 2008, Brantingham and Brantingham, 1995). These delayed

criminogenic effects may be reinforced for generator locations that are regularly visited by the same individuals such as soccer stadiums. The periodically recurring nature of home games as well as the requirement and habit of soccer fans to buy season tickets and attend home games as much as possible, ingrains the soccer stadium's location in fans' awareness spaces. This further raises its importance as an activity node for future offending. We argue that if crime generators exhibit a delayed criminogenic effect, then this should be quantifiable in crime patterns around episodically used crime generators. Empirically, we capitalize on a natural experiment in the city of Ghent, Belgium to study how the permanent closure of the city's national division soccer team's stadium impacts property crime rates on non-game days in the area surrounding the soccer stadium. We contrast temporal changes in property crimes on non-game days in the affected area with changes in citywide property crime rates.

As will be elaborated in the theory section, our approach is novel and important for two reasons. First, the conceptualization of crime generators suggests that crime patterns around generator locations are the combined result of the immediate (opportunistic) and delayed (premeditated) exploitation of criminal opportunities. Previous research has not considered this temporal distinction in crime levels around crime generators and has primarily highlighted the opportunistic and periodic nature of crime around crime generators. In our research, we move beyond the immediate and episodic nature of crime cluster formation around crime generators and consider the impact of the delayed exploitation of criminal opportunities on crime patterns near such locations.

Second, we capitalize on a natural experiment that entails the removal of a large sports venue. In doing so, we are able to disentangle a crime generator's individual effect on crime from the surrounding area's crime base-rate. This allows us to determine to what extent crime generators persistently boost crime in their environment while simultaneously taking environment-wide crime trends into account.

This article is structured as follows. In the next section, we discuss crime pattern theory, the concepts of crime generators, and spatiotemporal crime patterns around crime generators. Second, we describe the natural experiment and articulate our research hypothesis. We proceed with discussing the recorded crime data and the methods used to analyze the data. This is followed by a presentation and, finally, a discussion of the results.

CRIME PATTERN THEORY: AWARENESS SPACE AND CRIME GENERATORS

Crime pattern theory asserts that offenders' interaction with the physical and social environment influences their crime site choice (Brantingham and Brantingham, 1984, 2008, Brantingham and Brantingham, 1981, 1993). This theory posits that offenders look for suitable targets in areas they are familiar with, their so-called 'awareness space'. Like non-offending individuals, offenders perform a range of routine activities such as working, shopping, and engaging in recreational activities. While travelling from one daily activity to the other, offenders gain knowledge about the environment and become aware of criminal opportunities. They notice suitable targets and observe the absence of capable guardians. Only suitable targets near activity nodes or along traveled paths within an offenders' awareness space will be noticed. Most offenders will engage in crime site selection within the areas they are familiar with through performing their routine activities (Eck and Weisburd, 1995).

Brantingham and Brantingham (1995) argue that some places generate crime. Crime generators are public areas that are part of the awareness spaces of large numbers of people and are frequently visited during the course of individuals' daily routine activities.ⁱ These facilities generate opportunistic crime by bringing together in space and time large concentrations of people, including motivated offenders, for reasons unrelated to crime. Offender presence around crime-generating facilities is not primarily crime driven but may

lead to crime concentrations. While visiting these places, motivated offenders notice and exploit criminal opportunities immediately or on subsequent occasions. The opportunistic nature of crime around crime generators suggests that high-volume crime such as property offences will be the dominant crime type around these locations (Brantingham and Brantingham, 2003). This also implies that once crime generators cease operating, for example when they are permanently shut down, or when the supply of criminal opportunities is eliminated, for example by targeted crime prevention strategies, crime will drop in the surrounding area. Examples of crime generators include shopping precincts, mobility hubs, and large sports venues.

Interestingly, increased crime levels around crime generators are conceptualized as the combined result of the immediate and delayed exploitation of serendipitously observed criminal opportunities. Brantingham and Brantingham (1995) state that “mixed into the people gathered at [crime] generator locations are some potential offenders with sufficient general levels of criminal readiness that although they did not come to the area with the explicit intent of doing a crime, they notice and exploit criminal opportunities as presented (*either immediately or on a subsequent occasion*)” (emphasis added; see also Brantingham and Brantingham, 2003, Brantingham and Brantingham, 2008).ⁱⁱ This implies that crime generators' criminogenic effects break down into an immediate effect which results in temporary increases in crime while these facilities experience large visitor flows, and a delayed effect which extends beyond the crime generators' operating hours. This distinction highlights that crime generators may persistently raise crime levels in the surrounding area and not just at times those facilities are in use.

Offender-based research and ethnographic accounts of target-detection and target-exploitation strategies provide anecdotal evidence for the delayed exploitation mechanism. Offenders report that they primarily respond to serendipitous criminal opportunities encountered during

daily activities but sometimes look for targets around areas previously visited for legal routine activities. For example, whereas most property offenders indicate that they immediately exploit criminal opportunities encountered during routine activities, some reveal in offender-based research that they also return at a later time to exploit criminal opportunities identified earlier during noncriminal daily activities (see, e.g., Cromwell et al., 1991, 1999, Maguire et al., 2010, Nee and Taylor, 1988, Van Daele and Vander Beken, 2011, Wiles and Costello, 2000). Furthermore, offenders who engage in deliberate target searches have suggested in interviews that those searches are spatially clustered around areas visited earlier during legitimate activities (Maguire et al., 2010, Wright and Decker, 1994). In other words, the importance of frequently visited areas in the delayed exploitation of criminal opportunities is emphasized.

The opportunistic and episodic nature of crime around crime generators has been highlighted in various studies. Researchers have demonstrated for a variety of facilities that crime is elevated while such locations are open or are heavily used. For example, schools have been found to increase violent crime in the surrounding area during the school day and at times students are travelling to and from school (Roman, 2005), larceny peaks during rush hours in Washington metro rail stations (Irvin-Erickson and La Vigne, 2015), and the risk for violence is elevated in areas with a high density of alcohol outlets during time periods associated with the use of such premises (Roman and Reid, 2012). Haberman and Ratcliffe (2015) examine differences in temporal relationships among criminogenic places and find, for example, that street robbery is elevated only at times drug-treatment centers and pawn shops operate. Furthermore, they note that, in addition to robbery peaks during school hours, temporary flare-ups in street robbery occur around high schools outside school hours but when these premises are likely unofficially used by local residents. With regard to sports venues in general and soccer stadiums in particular, crime on game and non-game days has been

compared in four different studies and it has been determined that crime is elevated in the surrounding area on days and at times that sports venues are used (Breetzke and Cohn, 2013, Kurland et al., 2014a, Kurland et al., 2014b, Marie, 2016). Finally, it is revealed in some studies that crime levels remain elevated for a short time period after crime generating facilities have stopped operating and visitor flows have shifted, suggesting that crime generators' criminogenic effects may briefly persist beyond their opening hours. For example, Bromley and Nelson (2002) determined that alcohol- and nightlife-related violence and disorder continues for a short time period after bars and nightclubs have closed and violence remains slightly elevated around Stockholm metro stations after closing hours (Ceccato and Uittenbogaard, 2014).

Despite the growing body of research into the immediate criminogenic effects of crime generators, it is surprising that it has not yet been considered whether crime generators have a delayed impact on crime in their surrounding area when they are not open to the public or do not attract large numbers of visitors for other reasons. The current study was designed to address this and we examine whether crime generators impact crime in the surrounding area outside opening hours. If crime generators have a delayed criminogenic effect, this should be apparent around crime generators that are episodically used and, in particular, for those generators of which it is likely that recurring visitor flows ingrain their location in visitors' awareness spaces. Large sports venues such as soccer stadiums are archetypal examples of crime generators. Soccer stadiums and the surrounding area are regularly visited by large numbers of people, including motivated offenders, for reasons unrelated to crime (Breetzke and Cohn, 2013). They are therefore expected to be part of many individuals' awareness spaces. In contrast to earlier research (cf. Breetzke and Cohn, 2013, Kurland et al., 2014a, Kurland et al., 2014b, Marie, 2016), we argue here that while soccer stadiums' use is episodic, their effect on crime in the surrounding area is not limited to distinct events and

specific times but is persistent and extends beyond specific operating hours. This effect should cease to exist once recurring events stop taking place and the generators' initial importance as a node in individual awareness spaces degenerates.

THE NATURAL EXPERIMENT: A SOCCER STADIUM CLOSURE

In this study, we capitalize on a natural experiment in the city of Ghent, Belgium. We consider the 2013 closure of the city's national division soccer team's stadium as a case study to examine how crime generators impact property crime rates in the surrounding area outside opening hours.

The city of Ghent is situated in the northwestern part of Belgium and housed 253,266 residents on 1 January 2015 making it the third most populous city of Belgium. In June 2013, the city's national division soccer team, 'K.A.A. Gent', traded its original stadium for a new stadium in a multipurpose, commercial area in the city. The stadium used in this study, the 'Jules Ottenstadium', had been the soccer team's home ground since its construction in 1920 and held 12,500 seats. It was located away from main roads in a mid-density residential area in an eastern suburb of Ghent (see Figure 1) and was surrounded by a mixture of terraced and detached houses. The stadium was rarely used at full capacity requiring the club to sell cheap season tickets (De jonghe, 2008). In contrast to professional soccer stadiums in the UK or the Netherlands, the stadium was not consumer-oriented and did not host other event types.

Its presence in the residential area had become unwanted and caused antisocial behavior in the surrounding area on game days (De jonghe, 2008). Parking facilities and public transportation stops are dispersed across various locations in the neighborhood requiring stadium attendees to walk up to 1 km through the neighborhood on foot. Some retailers, bars and restaurants can be found in the wider area. During the Belgian professional soccer season, which runs

approximately from August until May, the stadium hosted biweekly soccer games. The last soccer game took place on May 23, 2013 and the stadium was officially closed with a fan event in early June 2013. It has since been demolished and a new residential neighborhood is currently being constructed on the stadium grounds.

The closure of the soccer stadium offers the opportunity to examine the effect of removing a crime generator from an area, that otherwise remains largely unaltered, on non-game day crime. By excluding game day crime and only including crime on non-game days, we are able to quantify the crime generators' delayed criminogenic effect and examine the impact of the delayed exploitation of criminal opportunities on crime levels in the stadium's surrounding area. Non-game day crime trends in the surrounding area before the stadium's closure act as counterfactual against which to compare changes in non-game day crime trends following the stadium's closure. Furthermore, we take into account that simultaneous citywide crime trends may play out in the study area and moderate the stadium's criminogenic effects. With the exception of the stadium's closure, the surrounding area remained largely unaltered. Market potential studies anticipated that the stadium's closure negative economic impact on nearby bars and businesses would be limited (De jonghe, 2008). Furthermore, the economic and demographic composition of the stadium's surrounding area remained largely unchanged from 2012 through 2014 (see Table 1). Finally, discussions with key informants at the Ghent Local Police Department confirmed that the stadium's closure was the main change in the surrounding area and a relatively isolated event. In summary, other potential crime generating facilities such as nearby retailers, bars, and restaurants were largely unaffected by the stadium closure and continued to operate after the stadium was demolished. This ensures a clearer look at the criminogenic effect of delayed exploitation of criminal opportunities.

[Table 1 HERE]

The choice of capitalizing on a soccer stadium (rather than an alternative type of crime generator) to test the delayed criminogenic effect of crime generators was based on the following two arguments. First, large sports venues such as a soccer stadium are prime examples of crime generators with discrete opening hours. Delayed exploitation may be anticipated and more easily detected around such venues for several reasons. Sports venues draw large crowds but are also flooded with police during opening hours. This may create an environment conducive for delayed exploitation. Although large crowds offer anonymity and may enable motivated offenders to remain undetected while exploiting nearby criminal opportunities, crowds could also increase the rate of capable guardians in the area. The increased police presence may deter motivated offenders at that time and encourage them to delay their exploitation of criminal opportunities. Additionally, most crime generators have discrete opening hours. Soccer stadiums, however, have very pronounced discrete opening hours. Soccer stadiums are mostly closed to the public and are only open for approximately six hours every fortnight. This creates a large time window to observe delayed exploitation. While, for example, bars or transportation hubs also have discrete opening hours, these locations alternate between open and closed more frequently and the time window to observe delayed exploitation is much smaller.

Second, like previous studies into crime generators' criminogenic effects, we assume that it is some of the crime generator visitors who commit offences nearby these locations. We also share with these studies the unavailability of detailed personal information on crime generator visitors and on the offenders associated with crimes nearby these locations to verify this assumption. However, our assumption may not be entirely unfounded since soccer stadiums are known to attract offenders (Breetzke and Cohn, 2013, Kurland et al., 2014a) and it is primarily young adult working-class men who regularly attend soccer games (Hardyns, 2006, Ofcom and Human Capital, X), a demographic associated with offending (Gottfredson and

Hirschi, 1990). The current soccer club's strategy of actively attracting young adults by selling cheap season tickets may have compounded this (De Jonghe, 2008).

In accordance with crime pattern theory, we expect that a crime generator, i.e. a soccer stadium, boosts crime in its surrounding area and that this effect extends beyond its opening hours. In particular, we hypothesize that the stadium's closure led to a reduction in property crime on non-game days in the surrounding area, relative to any simultaneous citywide trend.

[FIGURE 1 HERE]

DATA AND METHODS

Data

The crime data for this study consists of 16,425 property crime incidentsⁱⁱⁱ on non-game days committed in Ghent and recorded by the Ghent Local Police Department during a 36-month period from January 1, 2012 (18 months before the closure) through December 31, 2014 (18 months after the closure). The stadium closure (June 2013) divides this period into two 18-month comparison periods. Crime incidents before July 2013 are assigned to the pre-intervention group, while incidents from July 2013 onwards fall in the post-intervention group.

A concentric buffer around the soccer stadium defined the stadium's surroundings or treatment area (see, e.g., Breetzke and Cohn, 2013, Kurland et al., 2014b, Ratcliffe, 2012a). Lacking agreement in the literature on how far the influence of crime generators extends in the surrounding area (Groff, 2011, Payton et al., 2015, Ratcliffe, 2012a, b), we opted for a

1,250 m radius from the soccer stadium's center spot.^{iv} This radius corresponds with the approximate maximum distance spectators need to walk through the stadiums' surrounding area when attending soccer games and ensures having a measurable number of crimes in the direct vicinity of the stadium. In line with previous recommendations (Ratcliffe, 2012a), our buffer takes the local geography into account by including ancillary stadium facilities such as dedicated stadium parking lots and public transportation stops that are dispersed throughout the surrounding area. As such, we are able to closely capture the environment to which stadium visitors are exposed. When computing the treatment surface area, we take into account that the stadium buffer falls partially outside the study area (see Figure 1). Finally, the entire city with the exclusion of the area falling inside the treatment area serves as the comparison or control area. This approach allows us to account for citywide crime trends in monthly property crime totals and unmeasured crime policy changes that may impact crime across the city.

Property crime incidents were aggregated to monthly crime counts.^v Property crime is a custom-created offence category that pools incidents of burglary, shoplifting, theft from vehicle, and vehicle theft.^{vi} The recorded crime data include the date and time of the incident, the offence location and the incident type, and were geocoded with 1 m precision. Home game dates were extracted from the soccer team's website and removed from the data.^{vii}

Methods

The analysis breaks down into three parts, of which the third part is of primary interest to evaluate our hypothesis. First, we describe the recorded property crime data more in detail and highlight some differences between the pre- and post-intervention periods in property

crime counts around the stadium. This may be informative for understanding changes in property crime types in the wake of the stadium's closure.

Second, to begin appreciating the soccer stadium's criminogenic effect outside opening hours on property crime levels in its surrounding area, we initially present descriptive results on mean monthly crime totals on non-game days before and after the intervention took place. Over the course of the observation period, the stadium under study hosted 37 soccer games. An additional 36 soccer games took place at the new location. The intervention is the stadium's closure and monthly totals in non-game day property crime in the 18-month period after the stadium's closure (July 2013-December 2014) act as a counterfactual against which to compare monthly total in non-game day property crime in the 18-month period when the stadium was operating (January 2012-June 2013).

Third, we estimate difference-in-difference (DD) linear regressions with Newey-West standard errors (Newey and West, 1986) to compare the difference between the before-after differences in mean monthly property crime totals between the treatment and control area separately.^{viii} DD allows to estimate the average treatment effect of an intervention by comparing pre- and post-intervention differences in the outcome variable across the treatment and control group (Remler and Van Ryzin, 2014, Rosenfeld et al., 2014). This approach allows us to correct the initially observed delayed criminogenic effect of a soccer stadium for simultaneous citywide crime trends and tease out the full delayed criminogenic effect. When contrasting changes in the treatment area with changes in the citywide control area before and after the stadium's closure, monthly counts on non-game days are corrected for different area sizes of treatment and control area and are expressed as monthly totals per square kilometer. This ensures that crime rates in treatment and control areas are comparable. Each DD model includes a dummy coded indicator variable for the post-intervention group and for the treatment group. The pre-intervention group and the control group are the omitted contrasts.

The variable of interest is the interaction term between both indicator variables. This term captures the difference in difference in the outcome variable or the causal effect of the intervention. It indicates how much monthly property crime totals per square kilometer decreased (or increased) in the treatment area compared to the control area. If a criminogenic effect emanates from the soccer stadium on non-game days, then we expect to observe a steeper drop (or smaller increase) in property crimes on non-game days in the stadium's area after its closure. In particular, we seek to find a negative interaction term, which indicates a greater decrease in crime in the treatment area than in the control area in the event of a simultaneous citywide reduction in crime or a smaller crime increase in the stadium area should crime increase throughout the city.

RESULTS

Descriptive Results: Property Crime Incidents and Pre- and Post-Intervention Differences

[Table 2 HERE]

A detailed overview of counts of different property crime types on non-game days in the soccer stadium buffer is provided in Table 2. Burglary is the dominant property crime type around the soccer stadium (N = 253) followed by theft from vehicle (N = 108), and vehicle theft (N = 74). Shoplifting (N = 16) occurs infrequently around the soccer stadium.

[Table 3 HERE]

Table 3 provides descriptive statistics for pre- and post-intervention differences in mean monthly non-game day property crime totals for the soccer stadium buffer and the citywide

control area. First, we examine the overall trend in non-game day property crime throughout the control area. This allows us to appreciate the citywide crime trend. An 8.37% decrease in property offences is observed across the entire city. This suggests that property crime would have decreased in the areas surrounding the stadium regardless of any intervention.

Second, we focus on the stadium's surrounding area. In line with our expectations but not dissimilar to the citywide crime trend, monthly non-game day property crime totals decreased in the wake of the stadium's closure, dropping 42.85% in the 1,250 m buffer. On average, 6.83 fewer property offences are recorded monthly after the stadium's closure ($M_{pre} = 15.94$; $M_{post} = 9.11$).^{ix} At first sight, this supports our hypothesis that the stadium's closure led to a decrease in property crime in its surrounding area.

Difference-in-Difference Regression Model Results

[Table 4 HERE]

Although the descriptive results are suggestive, they are neither sufficient to conclude that the stadium's closure led to a decrease in property crime in the surrounding area nor that the stadium previously exhibited a criminogenic effect on non-game days. We observed a simultaneous citywide decrease in property crime after the stadium's closure compared to while the stadium was operating suggesting that the decrease in property crimes around the stadium may be by chance and not the result of a drop in previously elevated crime levels on non-game days in the wake of the stadium's closure. This complicates the interpretation of our initial result with regard to the stadium's area and is precisely the reason why we examine the change in change or difference in difference to establish the extent to which the observed change in property crime in the stadium's area is significantly larger (or smaller) than the

citywide trend. DD regression models with mean monthly property crime totals per square kilometer provide insight in the change of the change and help to achieve this goal.

Table 4 displays DD regression results for changes in monthly property crime totals on non-game days per square kilometer in the buffer around the stadium. The model results are relatively straightforward to interpret and confirm the descriptive results: Property crime dropped in the wake of the stadium's closure. The significant negative main effect for the post-intervention variable suggests that property crime per square kilometer decreased significantly in the stadium's area and the control area in the 18 months following the stadium's closure. The significant positive main effect of the treatment variable indicates that significantly more property crimes per square kilometer were committed across the stadium area than in the control area throughout the 36 month study period. However, the product term between the treatment and post-intervention variable is of primary interest. The significant negative interaction term indicates that the reduction in property crime per square kilometer in the stadium's area is significantly larger than the observed decrease in property crime throughout the city. In other words, the reduction in property crime in the stadium's area after it closed exceeds the citywide property crime drop. This provides support for our hypothesis that the stadium's closure led to a property crime drop in the surrounding area and suggests that the soccer stadium previously had a criminogenic effect on non-game days.

[Table 5 HERE]

Finally, the DD regression results allow us to quantify the stadium's criminogenic effect on non-game days while accounting for the citywide crime trend (e.g., Rosenfeld et al., 2014). This can be done by comparing the estimated difference in property crime on non-game days per square kilometer between the pre- and post-intervention period in the control area with the estimated change in the outcome variable between the pre- and post-intervention period in the

stadium's surrounding area (see Table 5). Given our study design, the estimated property crime levels per square kilometer across the control area in the 18-month period after the stadium's closure indicate what would have happened in the stadium's area should the stadium not have closed. Table 5 shows that a 8.49% decrease in property crime per square kilometer occurred in the citywide control area. Should the stadium not have closed, a similar 8.49% decrease in property crime would have been expected to occur in the stadium's area and property crime would have decreased from 4.85 incidents before the stadium's closure to approximately 4.44 incidents. However, the stadium closed and property crime counts on non-game days per square kilometer decreased with an estimated 42.89% from 4.85 to 2.77 property crime incidents on non-game days per month per square kilometer, an additional decrease of 34.40 percentage points beyond the citywide trend.

CONCLUSION AND DISCUSSION

In this study, we used a natural experiment in Ghent, Belgium to demonstrate that the presence of a soccer stadium locally raises property crime rates on non-game days. The purpose of the analysis was to test the existence of a delayed criminogenic effect of crime generators. Although this hypothesis is contained in crime pattern theory, it remained hitherto untested in the empirical literature.

Brantingham and Brantingham (1995) argue that certain facilities that are regularly visited by large numbers of people are crime generators. Elevated crime levels in and around crime generators have been attributed to a combination of the immediate and delayed exploitation of criminal opportunities. This entails that the criminogenic effect of crime generators may break down into an episodic and permanent effect (see Brantingham and Brantingham, 2003, 2008, Brantingham and Brantingham, 1995). Whereas the former effect leads to temporary increases

of crime around crime generators during opening hours only, the latter results in persistently raised crime levels around these locations. To date, only the former effect has been explicitly considered in research. Because in most empirical research no distinctions are made between crimes during opening hours and crimes during closing hours, all crime has implicitly been attributed to immediate exploitation. By drawing on a natural experiment that involved the definitive removal of a large crime generator in an area, we could examine the delayed exploitation mechanism and test whether soccer stadiums raise local property crime levels during closing days and do not receive visitors.

We examined 36-months of police recorded property crimes on non-game days to determine whether soccer stadiums persistently raise property crime levels in their surrounding environment. Our results support this assertion and confirm our hypothesis. We highlight that a delayed criminogenic effect emanates from generator locations. First, we determined that the soccer stadium's closure led to an estimated 42% reduction in property crime throughout the surrounding area and that this local crime reduction exceeded the simultaneous 8% citywide crime drop. This supports our conclusion that the stadium's closure initiated the local crime drop and could suggest that some of the visitors of the soccer stadium may have returned to the area on non-game days to commit property crime before its closure. This result demonstrates that the soccer stadium exhibited a delayed criminogenic effect on property crime prior to its closure.

Results from earlier research into crime around soccer stadiums established that crime near soccer stadiums is elevated on game days and that some of those visitors may be motivated offenders who immediately exploit criminal opportunities (Breetzke and Cohn, 2013, Kurland et al., 2014a, Kurland et al., 2014b, Marie, 2016). We now extend those previous studies by considering that motivated offenders among those visitors may wish to postpone their exploiting of criminal opportunities to non-game days. While a soccer stadium's use is

episodic in nature, its crime generating effect is found to be persistent and extends beyond game and event days. Our results thus support the classification of large sports venues such as soccer stadiums as crime generators and corroborates one of the central assertions of crime pattern theory: Nodes shared across many individuals' awareness spaces may lead to persistent clusters of crime. More importantly, we demonstrate that a crime generator's criminogenic effects is not necessarily directly tied to its temporary usage and provide empirical support for the conceptual distinction between immediate and delayed criminogenic effects.

An important advancement of our study is that it allowed to differentiate a crime generators' criminogenic effect from the crime-stimulating effect of the wider environment in which such facilities are embedded and simultaneously occurring crime trends in the environment at large. As such, we were able to quantify how much certain facilities boost crime beyond an area's crime base-rate and correct crime generators' criminogenic effects for citywide crime trends. The analysis presented here suggest that almost a third of all property crimes around this particular soccer stadium may be generated by the sports venue's presence in the area. The soccer stadium closure led to a crime reduction of 42% in the surrounding area that exceeded the citywide declining trend by nearly 35 percentage points. This result provides an initial insight into how much crime generators persistently boost crime beyond an area's crime base-rate and suggest that their impact on crime is significant.

Our results carry implications for crime pattern theory and the development of crime prevention strategies around generator facilities. We argue that other crime generators which experience similar visitor flow fluctuations but at shorter time intervals such as a weekly or daily basis may also exhibit delayed criminogenic effects and temporal crime spillovers. In particular, we project that the criminogenic effects of crime generators such as schools, shopping malls or mobility hubs extends beyond their opening hours and that crime levels

around these locations continue to be elevated at times that those locations do not experience large influxes of people. At first sight, the delayed effects may seem small or difficult to quantify but once crime counts have been normalized by an appropriate time interval such effects may become substantial. Researchers, however, will need to obtain detailed information on opening hours and will have to overcome the challenge of short time windows to observe delayed exploitation around these generator locations. Nevertheless, this dynamic may help to explain a number of results from previous studies such as the relatively small differences in crime levels across different times of the day around certain Philadelphia crime generators (Haberman and Ratcliffe, 2015) and the similarity of burglary count levels on game and non-game days around the Loftus Verfeld soccer stadium in Tshwane, South Africa (Breetzke and Cohn, 2013). In fact, it could be that previous researchers who were unable to determine temporal variation in the spatial distribution of crime around crime generators have inadvertently offered circumstantial evidence for a delayed criminogenic effect of such locations.

With regard to crime prevention strategies, law enforcement agencies, local residents and other stakeholders need to be aware that crime generators' criminogenic effects are not limited to opening hours. It is obvious to anticipate increases in crime during crime generators' opening hours but it is less straightforward to expect that generators' presence in an area continues to impact crime at times that these locations are not open to the public. Crime prevention schemes around crime generators may need to be adapted to our finding and could be extended by targeting crime generators at times they are not open. For example, while a temporary increase in law enforcement may be needed around soccer stadiums on game days to channel visitor flows and eliminate criminal opportunities, increased patrol schemes around sports venues on non-game days could also be justified in light of our results and could help to mitigate the delayed criminogenic effect of these locations. These

considerations may also be useful in urban planning, because they could inform policy makers' decision-making on where to build and where not to allow the construction of stadiums and other crime generators.

Finally, this study has some potential limitations that need to be considered and could be addressed in future research. Three important assumptions underlie our study. First, we expect that some of the stadium attendees are motivated offenders who return to the soccer stadium's area to commit property crimes. Although researchers previously studied soccer stadiums' immediate criminogenic effects and demonstrated that crime is elevated around soccer stadiums on game days (e.g., Kurland et al., 2014a, Kurland et al., 2014b), they did not establish that it is indeed soccer game attendees who are responsible for this temporary increase in crime. In fact, a variety of potential offenders could commit non-game day property crime in the stadium's environment, including stadium attendees delaying their exploitation of previously encountered criminal opportunities but also current and previous area residents (Bernasco, 2010, Bernasco and Kooistra, 2010), family members of area residents (Menting et al., 2016), and repeat offenders (Lammers et al., 2015). While residents, their family members, or offenders returning to a previous offence location will have committed some of the offences in the stadium's area, they are unlikely to be responsible for all of the property crimes recorded in the 18-months prior to the stadium's closure. Arguably, their share in the area's property crime rate may be captured by the property crimes we continued to observe in the post-intervention period. Nevertheless, future researchers will want to explore this assumption more in detail.

Closely related to the first assumption, is our second assumption that a soccer stadium's criminogenic effect extends beyond the stadium itself and is also linked to regularly used ancillary stadium facilities such as dedicated parking spaces and public transportation stops. By constructing a buffer around the soccer stadium we aimed to capture this in our study.

Ancillary facilities around the stadium are dispersed over a large area and required stadium attendees to walk relatively large distances. The locations of these ancillary facilities in relation to the soccer stadium impacts visitor flows and affects the paths visitors take and, ultimately, influence the opportunities motivated offenders may notice. In this study, it was not possible to examine whether exploited criminal opportunities indeed fell along travelled paths since we lacked information on visitor flows. In future studies, however, researchers may wish to study how visitor flows influence spatial patterning of crime around crime generators more in detail.

Third, we assumed that changes in property crime rates on non-game days in the stadiums' areas are driven by the stadium's closure. However, there is the possibility that changes in property crime rates may have been partially shaped by concurrent area-level changes in opportunities for immediate exploitation. For example, there could have been fewer non-game day visitors in the area due to nearby businesses closing down once the stadium permanently closed or changes in the economic and demographic composition of the area nearby the soccer stadium could have altered the available opportunities for crime. However, this is unlikely for three reasons. First, the socio-economic composition of the areas surrounding the soccer stadium remained unchanged during the 36-month study period (see Table 1). While area-level characteristics may affect the area's crime base-rate (Bernasco and Luykx, 2003), the results in Table 1 suggest that economic and demographic characteristics did not play a role in the observed property crime reduction around the soccer stadium. Second, if offenders were drawn to the stadium's area on non-game days to exploit criminal opportunities associated with other land uses then we would expect to see this reflected in the types of property crime that are committed in the area. However, Table 2 clearly shows that counts of all types of property crime, including those associated with commercial land use, went down in the wake of the stadium's closure. This suggests that it was unlikely that retailers or

commercial businesses drew offenders to the area on non-game days. Third, key informants confirmed that existing local bars and retailers in the stadium's area did not suddenly go out of business once the stadium closed.^x

Notwithstanding these limitations, we established that a delayed criminogenic effect emanates from soccer stadiums by determining that property crime remains elevated around these places when they are closed. Researchers and policymakers will want to take this into account when addressing the criminogenic effects of stadiums, malls, schools or railway stations. Instead of focusing solely on increases in crime at times these locations are drawing visitor flows, they but should carefully consider the possibility that these facilities continue to generate crime, even when they are not used.

ⁱ Crime pattern theory also includes 'crime attractors', a concept that is not discussed here because it is irrelevant for our main line of argument.

ⁱⁱ Later, Brantingham and Brantingham (2003: 147) added that "[d]elayed exploitation of a criminal opportunity discovered at a crime generator does not convert that location in a crime attractor".

ⁱⁱⁱ We focus on property crime (burglary, shoplifting, theft from vehicle, and vehicle theft) because it is generally more premeditated than other crime types and therefore more susceptible to delayed exploitation. The large volume of property crime also makes it better suitable for rigorous statistical analysis than other crime types.

^{iv} Similar results were found for buffers with radii of 500 m, 750 m and 1,000 m.

^v There are a limited number of property crime incidents recorded on a daily and weekly basis in the stadium's area. This prevents us from reliably estimating daily and weekly property crime trends. Instead, property crime counts are aggregated to monthly totals and monthly property crime counts are considered in the analysis.

^{vi} Vehicle theft includes car, bike, moped and motorcycle theft.

^{vii} Soccer games continued to take place in Ghent after the stadium's closure albeit on a different location. To ensure that property crime rates are computed similarly, game day crime is excluded in the pre- and post-intervention periods for the treatment and control area. This guarantees similar conditions when comparing crime trends before and after the closure as well as between the treatment and control group. For the sake of completeness: in the stadium's surrounding area, we observed 0.51 property crimes per game day and 0.57 property crimes per non-game day before the stadium's closure, and 0.47 property crimes per game day and 0.33 property crimes per non-game day after the closure. These rates suggest that for property crime the immediate crime effect of the stadium is limited or non-existent.

^{viii} Newey-West standard errors were estimated to address serial correlation and heteroscedasticity in our monthly property crime data (Newey and West, 1986).

^{ix} An unequal variances paired samples *t*-test confirms that this difference is statistically significant ($t = 4.53$, $p < 0.001$ one-sided). Test statistics are computed one-sided since we previously specified directional hypotheses: We assume that the removal of a soccer stadium in an area leads to a decrease in crime.

^x Simultaneous area-level change was the main reason to refrain from analyzing delayed exploitation around the new stadium. The new stadium was built in a multi-purpose commercial area that underwent considerable change during and after the stadium's construction. This makes it difficult to attribute any crime changes in the area to the opening of the stadium and its visitors. Moreover, the new stadium is consumer-oriented and host other event types that attract visitors on non-game days as well, making it difficult to unambiguously detect delayed exploitation around the new stadium.

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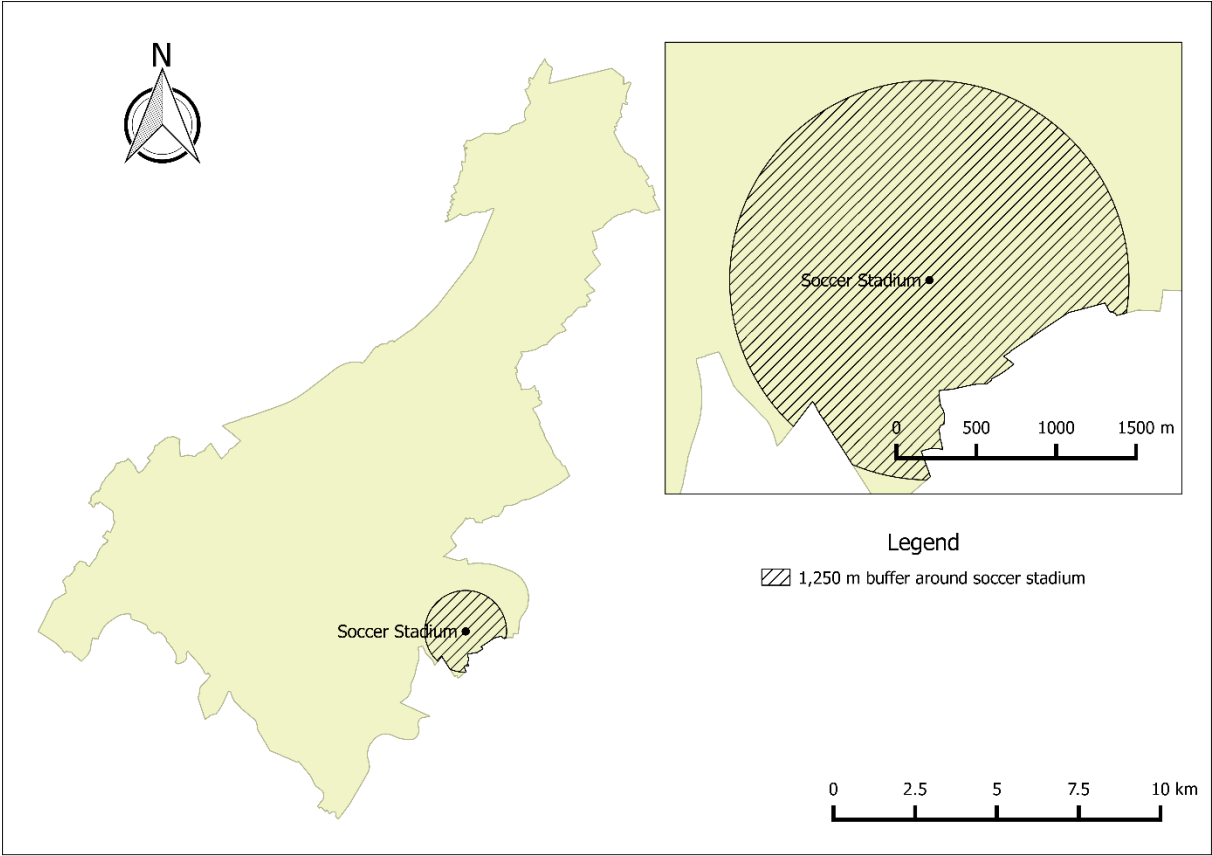


Figure 1 Map of soccer stadium's location in Ghent, Belgium with 1,250 m buffer

Table 1 Economic and demographic composition of the stadium's surrounding area

	<u>2011</u>	<u>2012</u>	<u>2013</u>
Population density (1,000/km ²)	3.18	3.21	3.22
Proportion unemployed residents (%)	4.03	4.77	5.07
Proportion single- parent families (%)	7.87	7.63	7.30
Proportion non- Belgian residents (%)	4.97	5.07	4.87
Median income (€1,000)	29.97	30.36	30.08
Note: Values are averaged across the only three census tracts with a residential function that fall entirely within the 1,250 m buffer area, including the soccer stadium's census tract.			
Sources: City of Ghent (2017), FOD Economie Algemene Directie Statistiek - Statistics Belgium (2017).			

Table 2 Property crime type counts on non-game days in 1,250 m soccer stadium buffer by pre- and post-intervention period

	<u>Before</u>	<u>After</u>	<u>Total</u>
Burglary	150	103	253
Shoplifting	12	4	16
Theft from vehicle	71	37	108
Vehicle theft	54	20	74

Table 3 Means and standard deviations (in parentheses) of raw mean monthly property crime counts on non-game days by experimental condition and pre- and post-intervention period

	<u>Before</u>	<u>After</u>
Treatment area (1,250 m buffer around stadium)	15.94 (5.76)	9.11 (2.70)
Control area (city with exclusion of 1,250 m buffer)	463.11 (54.09)	424.33 (46.66)

Table 4 Difference-in-difference regression models with Newey-West standard errors of stadium closure effect (treatment) on monthly property crime totals per square kilometer on non-game days around the stadium

	<u>1,250 m buffer around stadium</u>
Intercept	3.77*** (0.12)
Post-intervention ^a	-0.32* (0.15)
Treatment ^b	1.08* (0.47)
Post-intervention x Treatment	-1.76*** (0.51)
R squared	0.37
Adjusted R squared	0.34
F	13.21***
df	68
Number of observations ^c	72
^a 1 = post-intervention (18 months after stadium's closure), 0 = pre-intervention (18 months before stadium's closure)	
^b 1 = treatment area, 0 = control area	
^c DD model estimates are based on 36 consecutive observations of monthly property crime totals per square kilometer for the treatment and control group. Each 36-month period consists of two 18-month comparison periods before and after the intervention.	
* $p < 0.050$, ** $p < 0.010$, *** $p < 0.001$	

Note: To ensure comparability of property crime rates across different-sized treatment and control areas, monthly property crime totals per square kilometer are used.

Table 5 Predicted mean monthly property crime counts per square kilometer on non-game days by experimental condition and pre- and post-intervention period

	<u>Before</u>	<u>After</u>	<u>Percent change</u>
Treatment area	4.85	2.77	-42.89%
Control area	3.77	3.45	-8.49%