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Do Surveillance Cameras Affect Unruly Behavior? A Close Look at Grandstands*

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Abstract

How do surveillance cameras affect unruly spectator behavior? I examine this question using a natural experiment from the Swedish soccer league. Stadiums in Sweden introduced surveillance cameras at different points in time during the years 2000 and 2001. I exploit the exogenous variation that occurred because of differences across stadiums in the processing time taken to obtain permits for cameras as well as delays in the supply of equipment. Conditioning on stadium fixed effects, unruly behavior was found to be approximately 65 percent lower in stadiums with cameras compared to stadiums without cameras. The identification strategy provides a unique possibility to address problems regarding endogeneity, simultaneous policy interventions, and displacement effects.

Keywords: Crime; hooliganism; natural experiments

JEL classification: *J*01; *K*40

I. Introduction

In many countries, surveillance cameras have become a popular method in the attempts to combat crime. Estimates show that in the UK alone, over four million cameras have been installed.[1] While the cameras might reduce crime, this could come at high costs in terms of both management and, in particular, intrusion on privacy. The Fourth Amendment to the US Constitution, for example, often called upon by opponents to surveillance cameras, states that "the right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated . . .".

In order to motivate their use, surveillance cameras should consequently exhibit significant benefits. Becker (1968) was early to point out that

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[1] See the article, UK Privacy Watchdog Seeks More Powers, published by Associated Press, May 2, 2007 (available online at http://usatoday30.usatoday.com/tech/products/2007-05-02-2865134386_x.htm).

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criminals should respond to incentives. The higher the cost of crime, the less crime should be committed. An alternative theory holds that crime is a result of a complex set of economic, social, and biological factors. According to this view, law enforcement, such as surveillance cameras, would not be very effective (Cooter and Ulen, 2012). This is ultimately an empirical question, but it is hard to study in the sense that more crime might also increase the use of surveillance cameras.

In this paper, I study the effects of surveillance cameras on unruly spectator behavior inside soccer stadiums by exploiting a unique natural experiment from the highest Swedish soccer league. This application is important for several reasons. First of all, many potential spectators – around 37 percent, according to a recent Swedish study carried out by the Swedish Institute for Opinion Surveys (Sifo) using telephone interviews during 29–31 March, 2005 – do not dare to attend games because of various forms of hooliganism. In 2010, the annual income from ticket sales in the highest Swedish league was approximately 280 million SEK (EUR 25 million) (Sahlström, 2010). Incomes in the Premier League amount to almost £ 2.1 billion (EUR 2.5 billion), principally from ticket sales and television contracts.[2] If surveillance cameras deter hooliganism, then the soccer industry as a whole, and thereby consumer surplus, could be increased substantially. Moreover, the costs of policing soccer games in order to reduce unruly behavior are vast. In Sweden, the annual cost of policing of soccer games is approximately 70 million SEK (EUR 8 million).[3] In the Italian soccer championship, these costs amount to approximately EUR 40 million (De Biasi, 1997). The use of surveillance cameras could potentially reduce these costs.

The question is also related to a recent lively debate on the so-called "broken window theory", which holds that it is important to maintain urban environments in orderly condition and reduce petty crime in order to prevent escalation into more serious crime. In the words of former New York City Mayor, Rudolph W. Guiliani:[4] "There's a continuum of disorder. Obviously murder and graffiti are two vastly different crimes. But they are part of the same continuum, and a climate that tolerates one is more likely to tolerate the other."[5] A police officer with whom I have been in

[2] See the article, Record Income but Record Losses for Premier League, published by *The Guardian*, May 19, 2011 (available online at http://www.theguardian.com/football/2011/may/19/premier-league-finances-black-hole).

[3] See the article, Krav på hårdare straff (Demands for More Severe Punishment), published in Dagens Nyheter, February 12, 2007.

[4] See the archives of Rudolph W. Giuliani, Major Addresses 1998, The Next Phase of Quality of Life: Creating a More Civil City, February 24, 1998 (available online at http://www.nyc.gov/html/rwg/html/98a/quality.html).

[5] While the debate is far from settled, a large number of empirical studies support the hypothesis. For instance, using cross-sectional data on US cities, Sampson and Cohen (1988),

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contact has highlighted exactly this mechanism in the context of combating hooliganism. While not every incident constitutes a serious crime, early prevention is important so that other young hooligans will not engage in more serious crime. Moreover, as discussed below, cameras might have a similar effect in other comparable environments.

At various points in time, stadiums in Sweden have installed surveillance cameras in the grandstands. Only three stadiums had cameras in the 1990s. In accordance with new regulation from the Swedish Football Association, all stadiums that hosted clubs in the highest league had to have cameras installed in either 2000 or 2001.

The dates when cameras were introduced were, to a large extent, exogenous to previously unruly behavior. According to a senior official at the Swedish Football Association, the change in policy was not because spectators were particularly unruly during previous seasons, but rather that safety at Swedish arenas lagged behind the safety norms issued by the Union of European Football Associations (UEFA). For example, surveillance cameras have been used in England since the 1980s.[6] Moreover, the dates for the installation of cameras were not uniform, but differed across stadiums in Sweden during the years 2000 and 2001. This was because of administrative and budgetary considerations, as well as various delays in the provision of camera equipment.[7] The administrative processing time to issue permits for cameras typically varied from 30 to 90 days and, in one case, it was as high as 413 days.[8]

In this study, I use the different timing of the introduction of surveillance cameras inside the stadiums to estimate their effect on the number of incidents where objects (such as coins, bottles, and lighters) were thrown onto the field by spectators, as reported by the referees. During the soccer seasons 1999–2005, there were, on average, 0.26 incidents per game before the cameras were installed. Conditioning on stadium fixed effects, I find that games in stadiums with surveillance cameras had approximately 65 percent less unruly behavior inside the stadiums relative to before the installation.

In the literature on police and crime, it is often suggested that if crime is reduced in one area, it can be displaced to other areas. However, it

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MacDonald (2002), and Kubrin *et al.* (2010) have found a significant negative effect of police activity aimed at disorderly conduct on robbery rates.

[6] According to the official, "it is likely that experiences from outside Sweden, in particular from England, led to the decision to use surveillance cameras".

[7] According to the employee responsible for installation of the camera equipment, the work load of both the firm that provided the cables and the firm that installed the cameras affected the final installation dates substantially.

[8] In addition, in contrast to other clubs, the Stockholm clubs did not receive financial assistance from the municipality, which delayed their applications for permits.

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is difficult to assess this hypothesis empirically because crime can be displaced to many different locations. Here, I am able to address this issue, using unique data from the Swedish National Police Force on unruly supporter behavior outside stadiums, where the use of surveillance cameras is not permitted. The results indicate that the cameras do not displace unruly behavior.

The causality problem between police and crime has recently been addressed in the economics literature. Levitt (2002) uses gubernatorial elections as an instrument for policing and finds that policing tends to reduce crime. Using terrorist attacks as sources of exogenous variation in police, a recent body of literature shows that police presence reduces auto theft (Di Tella and Schargrodsky, 2004; Klick and Tabarrok, 2005), hooliganism (Poutvaara and Priks, 2009), and violence, theft, and sexual offences (Draca *et al.*, 2011)[9]. This body of literature reveals that the elasticities of crime with respect to police are approximately 0.3–0.4, so that a 10 percent increase in policing reduces crime by 3–4 percent.

Apart from Klick and Tabarock (2005), who have studied the effect of simultaneous interventions of police, cameras, and increased lighting on auto theft, and my previous work (Priks, 2014), showing that surveillance cameras deter crime in subway stations, I am not aware of any previous work on this topic in the economics literature. However, there exists a relatively large body of criminology literature and a number of British government reports that study how surveillance cameras affect street crime, burglary, and auto theft (for detailed reviews, see Welsh and Farrington, 2002, 2008). However, this body of literature typically suffers either because the installation of surveillance cameras was endogenous to previous crime,[10] or because several types of policing were adopted at the same time, or both. Moreover, the cameras themselves might, in addition to influencing criminals, also influence the behavior of the potential victims of crime, which makes it difficult to isolate their deterrent effect.[11] The simple fact that more crimes are spotted by the cameras also blurs their deterrent effect.

The use of unique data allows me to address these concerns. The endogeneity problem is, by and large, excluded and, importantly, there were no other policy interventions at the same time as cameras were installed in 2000 and 2001. The deterrent effect of the cameras can be further isolated because the referees who filed the reports on unruly behavior did not use

[9] Moreover, Machin and Marie (2011) have studied policy initiatives when particular police forces were given more resources to combat crime.

[10] For example, if surveillance cameras are installed because of an increased level of crime, then individuals who are potentially subjects to crime might change their behavior as a result of the elevated crime level rather than because of the cameras.

[11] For example, individuals could report more crime to encourage the use of cameras, or take more risks in response to the existence of cameras.

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information from the cameras. Moreover, in contrast to many other types of crime, the victims of the type of unruly behavior I consider (players, referees, and other supporters) can hardly change their behavior because of the existence of the cameras. Finally, in contrast to the literature on police and crime, which assumes that a change in policing can be observed by criminals, the signs indicating that cameras have been installed are required by law to be visible and the cameras themselves are often clearly visible.

When identification problems are set aside, the overall result from the previous literature indicates that cameras deter property crime in parking lots. A recent thorough study by King *et al.* (2008) also shows that cameras on street corners deter property crime close to the cameras (up to 30 feet away). My analysis adds to this literature by showing that cameras are efficient in another well-contained environment where camera signs are visible (i.e., in soccer stadiums).

The outline of the paper is as follows. I describe the data and the empirical strategy in Section II. In Section III, I report the results. I analyze the displacement effect in Section IV, and in Section V, I provide a model that is used to discuss the external validity. I conclude in Section VI.

II. Data

I study information on the use of closed-circuit television surveillance systems (surveillance cameras) in the different soccer stadiums used by the highest Swedish soccer league, *Allsvenskan*. Cameras were installed in several stadiums in 1992, when Sweden hosted the European Championship. However, they continued to be used only in Nya Ullevi Stadium in Gothenburg and in Råsunda Stadium in Solna, adjacent to Stockholm. Apart from Olympia in the city Helsingborg, which had cameras installed before the 1999 soccer season, the other stadiums did not have surveillance cameras during the 1990s. Prior to the 2000 season, a decision was taken by the Swedish Football Association whereby surveillance cameras had to be installed within two years in all stadiums that hosted soccer in the highest league. An important reason for this decision was that Sweden lagged behind the European safety standards in soccer stadiums set by UEFA. According to officials at the Swedish Football Association, the change in policy regarding cameras was, in any event, not a result of any previous change in unruly spectator behavior.

Surveillance cameras were installed in the stadiums at different points in time during 2000 and 2001 (or later, if a newcomer entered the league). The timing of the installations differed for several reasons. Permits to use surveillance cameras are issued by county administrative boards, and local administrative delays differed across the country. In addition, in contrast to municipalities outside Stockholm, the Stockholm municipality did not

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Table 1. *Introduction of surveillance cameras*

Name of stadium	Home club	Proc. time (days)	Installed
Råsundastadion	AIK	57	1987
Nya Ullevi	Göteborg	730	1991
Olympia	Helsingborg	30	April 9, 1999
Gamla Ullevi	Örgryte, GAIS	90	July 4, 2000
Örjans Vall	Halmstad	31	July 13, 2000
Idrottsparken Sundsvall	Sundsvall	62	July 13, 2000
Ruddalens IP	Västra Frölunda	41	July 14, 2000
Rambergsvallen	Häcken	46	July 14, 2000
Parken	Norrköping	52	July 19, 2000
Eyravallen	Örebro	35	July 21, 2000
Stockholms Stadion	Djurgården	85	August 18, 2000
Ryavallen	Elfsborg	30	September 7, 2000
Vångavallen	Trelleborg	71	October 9, 2000
Söderstadion	Hammarby	413	October 13, 2000
Malmö Stadion	Malmö	49	April 4, 2001

financially assist the clubs in purchasing and installing the cameras, which delayed the applications in Stockholm.[12] Moreover, according to an employee responsible for installation of the cameras, delays in the provision of the cable work and the camera equipment affected the dates of the installations in the various stadiums. The permits are issued to the owner of the stadium, and the Swedish National Police Force operates the cameras. If there are indications of unruly behavior, the police peruse the tapes in order to find the perpetrator. Table 1 shows the processing time for the various clubs to obtain permits, and the time at which surveillance cameras were installed. The time varied from 30 days (Ryavallen, used by IF Elfsborg) to 413 days (Söderstadion, used by Hammarby IF).[13] The installation of cameras took place during the time period July 4, 2000 to April 4, 2001.

According to Swedish law, surveillance cameras have to be indicated by clear signs. In the arenas, this is publicly indicated by signs showing a picture of a surveillance camera, typically placed at all entrances as well as inside the stadiums. The directives from the Swedish Football Association regarding the position of the cameras are that they "should be able to cover the whole arena". However, the licences do not permit any

[12] The information on surveillance cameras has been provided by the Swedish Football Association, the head of the Sport Intelligence and Tactical Unit at the Swedish National Police Force in Stockholm, the former head of the arena security department of the club Hammarby IF, and the employee in charge of installation of the cameras at the firm MKS Säkerhetsprodukter.

[13] It took much longer to issue a permit to Nya Ullevi in 1992, but this is outside the time period under study.

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Fig. 1. Photographs of the signs at the entrances and the cameras inside the stadiums

surveillance outside the stadiums. Figure 1 shows photographs of the signs at the entrances and the cameras inside the stadiums.

I use the variation in the timing of the installation of surveillance cameras to analyze how they affect unruly spectator behavior. Spectators sometimes throw objects, such as coins, bottles, lighters, firecrackers, batteries, snuff boxes, etc., onto the playing field. According to the head of the Sport Intelligence and Tactical Unit at the Swedish National Police Force, these individuals are not necessarily violent hooligans who systematically fight with each other, but more likely ordinary supporters. It takes a fair amount of determination to hit the pitch, and the objective is, presumably, to hit either players or referees. This is, of course, unlawful behavior, which can be dangerous. There are two types of punishments for unruly spectator behavior. In serious cases, when someone is struck by objects, for example, the case can go to court. In addition, the perpetrator's club might have to pay a fine amounting to EUR 11,000–27,000. According to the supervisor of a large Stockholm police unit in charge of police deployment at soccer games, the cameras were indeed used during the time period under study in both investigations and subsequent trials.

When objects are thrown onto the field, the referees report the number of incidents and from which supporter section the objects came, in their regular game report.[14] I have access to information from these reports during the time period 1999–2005. There are 26 playing rounds per year. Out of a total of 1,273 games, 211 games were played without surveillance cameras. Table 2 shows the summary statistics on unruly behavior. There were, on average, 0.26 incidents per game without surveillance cameras, and 0.21 incidents per game with cameras. As a robustness check, I have also constructed a variable that takes the value of one if there were one or more incidents in a game, and zero otherwise. There were incidents in

[14] This covers most of the unruly behavior that takes place inside the stadiums.

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Table 2. *Summary statistics for incidents inside stadiums*

	Mean	Std dev.	Min	Max	Obs.
Before cameras					
Total number of incidents per game	0.26	0.72	0	4	211
Games with incidents = 1	0.16	0.36	0	1	211
After cameras					
Total number of incidents per game	0.21	0.68	0	5	1,062
Games with incidents = 1	0.12	0.32	0	1	1,062

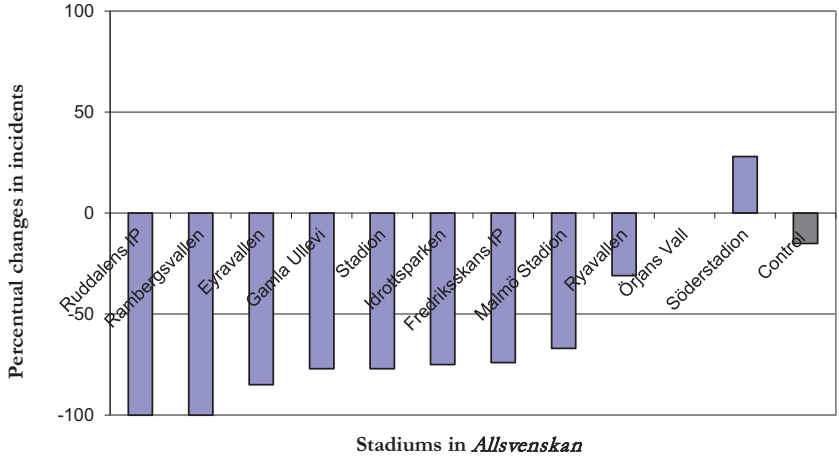

Fig. 2. Changes in the number of incidents when cameras were introduced

16 percent of the games with cameras, and in 12 percent in games without cameras.

Figure 2 depicts the percentage changes in the number of unruly incidents inside stadiums as a result of the introduction of surveillance cameras. It shows that nine stadiums exhibited fewer incidents during the periods with surveillance cameras, compared to without cameras. Eight of the reductions were very large, well over 50 percent. One stadium had the same number of incidents per game with and without cameras, and one stadium in fact experienced more incidents during the period with cameras.[15] The stadiums Nya Ullevi in Gothenburg, Råsundastadion outside Stockholm, and Olympia in Helsingborg, had cameras before the 1999 season and

[15] Because there were no incidents at all before the cameras were introduced in Norrportens Arena (where IFK Sundsvall plays) and Vångavallen (where Trelleborgs FF plays), these observations cannot be reported in the figure. In the case of Norrportens Arena, this is partly because there were only five observations before the introduction of the cameras. However, there were slight absolute increases in unruly behavior during the periods when cameras were used (0.07 incidents per game in Norrportens arena and 0.14 in Vångavallen).

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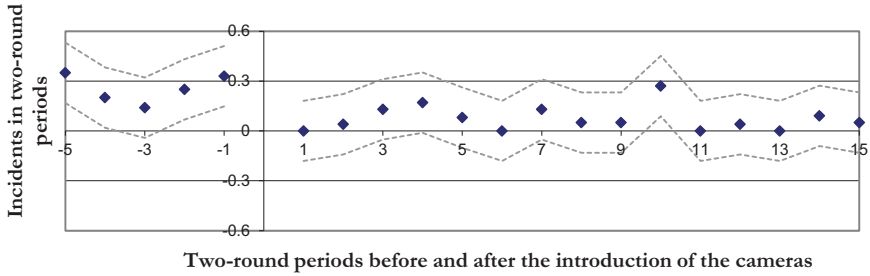

Fig. 3. Incidents 10 rounds before and 30 rounds after the introduction of the cameras

serve as a control group.[16] Taken together, they experienced a very small reduction in unruly behavior during the period with cameras.[17]

In order to exclude the possibility that the reduction in the number of incidents had not taken place already before the installation of cameras, the analysis focuses on the number of incidents during the periods before and after the introduction of surveillance cameras. In Figure 3, I collapse the number of incidents into two-round periods, stadium by stadium, and depict five such periods before the installation of cameras and 15 periods after. In other words, the data are now normalized around the date of the introduction of cameras. The dotted lines denote the standard deviations. There is a clear downward jump at the time of the introduction of cameras. In the five two-round periods before the installation of cameras, there were, on average, 0.25 incidents per game. However, in the 15 two-round periods after the installation of cameras, the average was 0.07 incidents per game. Hence, in this interval, the reduction in the number of incidents amounts to 72 percent.[18]

In order to test whether surveillance cameras affect the extent to which spectators throw objects, I used the following set-up. Let $Y_{ijt}+$ denote the

[16] All Stockholm derbies between AIK, Djurgårdens IF (normally playing at Stockholms Stadion), and Hammarby IF (normally playing at Söderstadion) took place at Råsundastadion, where surveillance cameras were in use throughout the time period considered. These derbies are therefore included in the control group.

[17] In order to illustrate the changes in the control group, an assumption has to be made regarding the timing of the introduction of cameras. Here, I take this to be the timing of the second largest stadium in the city or region (July 4, 2000 for Nya Ullevi, August 18, 2000 for Råsundastadion, and April 4, 2001 for Olympia).

[18] The figure only includes stadiums that had games both with and without surveillance cameras. Kalmar FF played in the highest league without cameras in 1999 and then again in 2002 with cameras. Because of the large time difference, Kalmar FF is not included in the figure, but its inclusion would not have any substantial effect on the results.

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number of incidents in game j in stadium i at time (round) t. Then, I ran the regression

$$Y_{ijt} = \alpha_i + \beta camera_{it} + m_t + v_{ijt}, \quad (1)$$

where α_i is a stadium fixed effect and m_t is time fixed effects.[19] The parameter β measures the effect of having cameras in place on unruly behavior by spectators. In other words, I compare the behavior of supporters in the same stadium in a game with cameras to a game without cameras.[20]

The full dataset contains games between 1999 and 2005. One way of controlling for time trends in the outcome variable is to use a full set of dummy variables for every round. However, this is not feasible in practice, because the panel dataset consists of only 13 cross-sectional units, but there are 182 rounds. Instead, I have controlled for time trends with month fixed effects because there might be seasonal variation in unruly spectator behavior. For example, it could have increased at the beginning and at the end of the soccer seasons. Thus, because the season begins in April and ends in November, I added nine indicator variables for the month in which the game took place. Another possibility is that there could have been stadium-specific trends, which I also controlled for. The most convincing method is perhaps to reduce the sample size and to focus on what happened in the brief periods before and after the introduction of cameras at the different stadiums. Because the introduction of cameras took place at different points in time, in a sufficiently short time interval, trends cannot be important for the results. Therefore, I focused on this method in the subsequent regressions. First, I included games one year before and one year after the introduction of cameras. Each team plays 13 games in a year.[21] Then, I used a sample with six games before and six games after the introduction of cameras, which is followed by four games before and after. Finally, I included only two games before and after the introduction of cameras.

[19] As mentioned above, Djurgårdens IF and Hammarby IF have played their derby home games against each other and against AIK at Råsundastadion. I treat Djurgården's and Hammarby's home games at Råsunda separately and differently from when they play in their usual home stadiums (Stockholms Stadion and Söderstadion). However, the results are not sensitive to this assumption.

[20] I use OLS specifications because they provide consistent estimates under relatively weak assumptions. However, if anything, using Probit, Tobit, or Poisson specifications strengthens the results.

[21] For some stadiums included in the regressions, there are fewer than 13 observations before the cameras were introduced.

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Table 3. *Surveillance cameras and unruly behavior inside stadiums*

	Sample 1	Sample 2	Sample 3
Surveillance cameras	−0.16**	−0.16**	−0.27**
	(0.07)	(0.08)	(0.10)
Month fixed effects	No	Yes	Yes
Linear stadium specific trend	No	No	Yes
R^2	0.11	0.11	0.13
Observations	1,273	1,273	1,273

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The full dataset (1999–2005) is used. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

Table 4. *Surveillance cameras and unruly behavior inside stadiums: reduced sample size*

	Sample			
	One year	Six rounds	Four rounds	Two rounds
Surveillance cameras	−0.21**	−0.16**	−0.20	−0.21
	(0.09)	(0.07)	(0.12)	(0.20)
R^2	0.09	0.12	0.19	0.30
Observations	354	165	112	56

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

III. Results

Tables 3 and 4 report the main results. Column 1 in Table 3 shows the results for the full sample (1999–2005) using only stadium fixed effects. The estimated effect is that games with cameras had 0.16 fewer incidents than games without cameras. This amounts to a 64 percent reduction compared to the average number of incidents without cameras, 0.26. In Column 2, I add month fixed effects. The estimated effect and the standard error remain almost the same. In Column 3, I add stadium-specific linear trends. The coefficient has, if anything, increased and the significance remains the same. In Table 4, the sample size is reduced in order to focus on the effects in the time periods close to the introduction of cameras. As expected, when the sample size is reduced, the precision in the estimates is also somewhat lower. Importantly, the estimated effect of the variable, surveillance cameras, remains strikingly similar independently of the sample size. It fluctuates between −0.16 and −0.21. When using a relatively larger sample size, a potential concern is that trends might bias the results. However, because the coefficient remains almost identical, this does not

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Table 5. *Surveillance cameras and unruly behavior inside stadiums (0,1)*

	Sample 1	Sample 2	Sample 3
Surveillance cameras	−0.09M**	−0.08**	−0.15**
	(0.04)	(0.04)	(0.05)
Month fixed effects	No	Yes	Yes
Linear stadium specific trend	No	No	Yes
R^2	0.09	0.09	0.11
Observations	1,273	1,273	1,273

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The full dataset (1999–2005) is used. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

Table 6. *Surveillance cameras and unruly behavior inside stadiums: reduced sample size (0,1)*

	Sample			
	One year	Six rounds	Four rounds	Two rounds
Surveillance cameras	−0.12**	−0.10**	−0.14**	−0.18*
	(0.05)	(0.04)	(0.05)	(0.10)
R^2	0.09	0.10	0.21	0.38
Observations	354	165	112	56

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

seem to influence the results. The analysis therefore strongly suggests that the introduction of cameras reduced unruly behavior inside the stadiums.

Because the number of incidents per game varies, I next checked that the results are not driven by a few games with many incidents. The dependent variable now takes the value of one if there were one or more incidents in a game, and zero otherwise. Table 5 reports the results for the full sample. Column 1 shows that the number of games with incidents was 9 percent lower in games with cameras compared to games without cameras. This amounts to a 56 percent reduction because there were, on average, incidents in 16 percent of the games without cameras. The result is significant at the 5 percent level. Column 2 adds month fixed effects and the estimated effect is the same. The significance remains high when a stadium-specific linear trend is added in Column 3. Table 6 shows that the estimated effect is similar when the sample size is reduced. If anything, it is larger in the interval close to the introduction of cameras. The results are significant in all specifications. As placebo treatments, I studied the effects in various periods before the actual intervention of cameras. Table 7 shows that there were no significant changes in unruly behavior in these periods.

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Table 7. *Placebo treatments*

	Sample 1	Sample 2	Sample 3
Surveillance cameras	−0.31*	−0.24**	−0.26**
	(0.16)	(0.10)	(0.12)
Surveillance cameras minus three rounds	0.05		
	(0.12)		
Surveillance cameras minus six rounds		−0.06	
		(0.10)	
Surveillance cameras minus nine rounds			−0.03
Month fixed effects	Yes	Yes	Yes
Linear stadium specific trend	Yes	Yes	Yes
R^2	0.13	0.13	0.13
Observations	1,273	1,273	1,273

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

Table 8. *Surveillance cameras and unruly behavior inside the stadiums: collapsed data*

	Sample 1
Surveillance cameras	−0.18**
	(0.07)
R^2	0.73
Observations	36

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

A concern regarding these OLS regressions is that because of potential serial correlation, they might underestimate the standard errors.[22] As a robustness test, I therefore collapsed the whole dataset for each stadium into two observations, one before the introduction of cameras, and one after. Table 8 reports the results. The estimated effect is similar to earlier results, −0.18, and the significance remains high.

It is possible that more spectators attend soccer games if they feel safer because of the cameras, and this could change the total amount of unruly behavior. When the composition of the spectators changes, a more pleasant atmosphere could arise, which would reduce the total number of incidents. To control for this, I used the total number of incidents per game and per spectator (multiplied by 1,000) as the dependent variable. This method is feasible in the sense that most games are not sold out. The average for this dependent variable in games without cameras is 0.04. Column 1 in Table 9 shows that the use of cameras reduces the number of incidents per

[22] See Bertrand *et al.* (2004) for a discussion of, and solutions to, this problem.

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Table 9. *Surveillance cameras and unruly behavior per spectator inside stadiums*

	Sample				
	Full dataset	One year	Six rounds	Four rounds	Two rounds
Surveillance cameras	−0.05**	−0.04**	−0.03*	−0.04*	−0.04
	(0.02)	(0.02)	(0.01)	(0.02)	(0.03)
R^2	0.08	0.08	0.08	0.18	0.28
Observations	1,272	354	165	112	56

Notes: The dependent variable is the number of incidents with objects thrown onto the field. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively. The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums. The first regression includes month fixed effects and stadium specific linear trends.

Table 10. *Surveillance cameras and the number of police officers*

	Sample	
	Full dataset	One year
Number of police officers per game	0.14	−1.10
	(0.26)	(1.17)
R^2	0.19	0.26
Observations	785	153

Notes: The dependent variable is the surveillance cameras (0,1). The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

spectator by 75 percent. While the standard error is lower when the sample size is reduced, the estimated effect is very similar.

A potential problem when studying surveillance cameras and crime is that many interventions often occur at the same time. If the number of police officers is increased at the same time as cameras are installed, then only the joint effect can be estimated. However, fewer police might also be ordered as a consequence of the installation of cameras, because the two types of law enforcement might be complements. In my contacts with police sources, I found no evidence that the number of police officers at the games was changed around the time when the surveillance cameras were installed. Nevertheless, I performed a placebo treatment to study whether the number of police officers at the games was different in the games with cameras compared to those without.

The data on the number of police officers at the games were obtained from the Swedish National Police Force. On average, there were 19 police officers per game without cameras, and 25 police officers per game with cameras. Table 10 shows how the use of cameras is related to the number of police officers. This table shows that there is no significant difference in the number of police officers before and after the installation of surveillance

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cameras. This reinforces the information from the police force that the number of police officers who work with unruly spectator behavior has not been related to the use of surveillance cameras. The reduction in unruly behavior can therefore be fully derived from the use of cameras.[23]

In summary, all specifications point in the same direction. The introduction of surveillance cameras in the Swedish soccer stadiums had a very large deterrent impact on unruly supporter behavior.[24]

IV. Displacement Effects

A classical problem in the literature on crime is that when unruly behavior in one location is reduced, it can be displaced elsewhere. It is difficult to address this issue empirically, however, because crime might be displaced to so many locations. I have access to unique data on unruly behavior outside stadiums, which I was able to use to study this effect. If incidents are reduced inside the stadium, then the displacement theory predicts that there would be more incidents outside the stadiums where it is not permitted to set up cameras. I use information from the Swedish National Police Force on disturbances outside the stadiums. The police data capture incidents, such as fights and throwing of stones or bottles between supporters of different teams or against the police. The location is often immediately outside the stadium and sometimes in the town where the game is played. Importantly, because the cameras are permitted only inside the stadiums, they cannot affect this unruly behavior directly.

The dependent variable, disorder outside the stadiums, takes the value of one if a disorder has occurred, and zero otherwise. There were, on average, 0.08 incidents before the introduction of cameras and 0.10 incidents per game after.

In order to study whether there were any changes in unruly supporter behavior before and after cameras were introduced inside the stadiums, I estimated equation (1) with disorder outside stadiums as the dependent variable. Table 11 shows the results when the dependent variable is disorder outside the stadium. First, I used the full sample, and then a smaller sample containing games from one year before and one year after the introduction

[23] Because the number of police officers is an endogenous variable, I have not included it in the regressions with surveillance cameras and unruly behavior. However, its inclusion would not change the results qualitatively.

[24] The results are also robust to the inclusion of different fixed effects, such as game fixed effects and team fixed effects, as well as various placebo treatments. Moreover, attrition and entry in the panel, as well as the exclusion of Stockholm games, do not affect the results qualitatively.

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Table 11. *Surveillance cameras and unruly behavior outside stadiums*

	Sample	
	Full dataset	One year
Surveillance cameras	−0.01	−0.02
	(0.02)	(0.06)
R^2	0.10	0.09
Observations	860	169

Notes: The dependent variable is the disorder outside the stadium (0,1) . The regressions include stadium fixed effects and the standard errors are clustered at the level of the stadiums.

of cameras.[25] Column 1 shows that unruly behavior outside stadiums was not significantly different in games with cameras compared to those without cameras. Column 2 confirms this when the smaller sample is used.[26]

In summary, the data strongly suggest that the unruly behavior inside stadiums that was reduced after the introduction of cameras was not displaced to unruly supporter behavior outside the stadiums.

V. Discussion of the External Validity

Now, I introduce a simple model in order to discuss how surveillance cameras influence unruly behavior in the stadium as compared to other environments.[27] Individuals receive utility $u(c)$ of committing a crime, where c reflects the intensity of the crime. The cost of committing a crime is that it might be detected, which happens with a probability $m(c, \theta)$, in which case the individual incurs the cost r. The parameter θ reflects how efficient monitoring is. I assume that $m_c(c, \theta) > 0$, $m_\theta(c, \theta) > 0$, and $m_{c\theta}(c, \theta) > 0$. In order for the cameras to be efficient, the offenders have to be aware of the presence of cameras. Criminals must also take the cost of their crime into account. Findings in cognitive psychology, for example, show that some people are too short-sighted to be affected by crime sentences (Cooter and Ulen, 2012). The extent to which individuals are sensitive to detection and punishment is captured by the parameter α.

A potentially criminal individual therefore solves

$$\max_c u(c) - \alpha m(c, \theta) r. \tag{2}$$

[25] The police have not reported information from the year 2000. Because most observations would be missing, it is not sensible to use smaller windows around the time of introduction of cameras.

[26] The results do not change when controlling for month fixed effects or linear trends.

[27] This is a modified version of the leading work by Becker (1968). For related models, see Garoupa (1997).

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The functions $u(c)$ and $m(c, \theta)$ are assumed to be twice continuously differentiable everywhere and, for large c, the endpoints are such that a solution exist.

The first-order condition is given by

$$u_c(c) - \alpha m_c(c, \theta) r = 0. \tag{3}$$

I assume that the second-order condition holds. Using the implicit function theorem, it follows that $\partial c/\partial \theta < 0$, $\partial c/\partial \alpha < 0$, and $\partial c/\partial r < 0$.

The technology parameter θ is high when cameras can cover an area efficiently. Good examples of such areas would be parking lots, subway stations, and soccer stadiums, where many individuals are concentrated in one area and the cameras can be assumed to operate well. In open areas, such as parks, in contrast, it is expensive to fully cover such areas and θ is therefore lower. Earlier literature shows that cameras are efficient in parking lots (Welsh and Farrington, 2008) and in subway stations (i.e., Priks, 2014, has shown 20 percent reductions in crime rates). There is also some evidence that surveillance cameras are efficient on streets, but only in the immediate surroundings of the cameras where θ is high. King *et al.* (2008) have exploited the introduction of surveillance cameras on streets in San Francisco, where problems of endogeneity of the intervention and simultaneous policy interventions could be excluded to a large extent. They have shown that larceny theft was reduced by approximately 20 percent in areas up to 100 feet away from the cameras, but not farther away.

Consider now the parameter α. At stadiums, camera signs can be clearly displayed at the entrances and α is therefore high, which should lead to a large deterrent effect, as found in the paper. In other areas, where signs were not present or where they are more difficult to detect, cameras seem to be less efficient (Welsh and Farrington, 2008). The parameter α can also be lower for violent crime than for planned crimes, because violent offences are often crimes of passion. When individuals fight for instance, they might be too emotionally involved to care about the threat of detection represented by cameras. The literature shows that violence on the street and in subway stations tends to be unaffected by surveillance cameras, whereas planned crime, such as pickpocketing or drug dealing, tends to be deterred (King *et al.*, 2008; Priks, 2014). Throwing objects inside stadiums is also a violent act but, in contrast to street violence, it is unilateral, which probably increases self-control and awareness of cameras (i.e., α is higher). A final reason for a high α inside stadiums is that the throwing of objects can – just as planned crime – be strategic and therefore sensitive to law enforcement.

The parameter r captures the punishment for the crime. The type of crime I study here is a relatively mild form of assault and the punishment is similar to mild assaults outside the stadium (normally a fine, possibly

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prison). However, one difference is that the clubs also have to pay fines, which increases r if the offenders care about their club's economy.

In summary, the fact that cameras reduce unruly behavior inside stadiums to a larger extent than has been found in the previous body of literature can be explained by the circumstances that the area is well defined and easy to monitor (high θ), with clearly visible signs and possibly where offenders have a high awareness (high α), and where the penalty might be relatively large given the type of crime committed.

VI. Concluding Remarks

The use of surveillance cameras has become a widespread means of reducing crime. However, in the sense that intrusion on privacy is a serious concern, the effectiveness of the cameras should be carefully evaluated. The study of their deterrent effects is associated with a number of severe problems. For example, cameras are often adopted when crime is particularly serious. Moreover, cameras are often combined with other measures. The deterrent effects are furthermore blurred by the fact that cameras might affect the precautions taken by potential victims of crime, and might change the intensity with which they report crime. In addition, whenever cameras are used to detect crime, their deterrent effect is frequently obscured.

These concerns are addressed in this paper by means of a natural experiment and unique data on unruly spectator behavior. The timing of the introduction of cameras was, to a large extent, exogenous to previous unruly behavior, and there were no other policy interventions at the same time as the introduction of cameras. In addition, the referees who filed the reports on unruly behavior did not take information from the cameras into account. This allowed me to isolate the effect of surveillance cameras on unruly spectator behavior.

The results show that there was much less unruly behavior inside stadiums when surveillance cameras were used compared to the games when they were not used. The various specifications reveal that the reduction was at least 65 percent.

The total cost of installing the cameras in Swedish stadiums was approximately EUR 160,000 and they last for eight years, which implies an annual cost of EUR 20,000. According to my estimates, the cameras deter approximately 36 incidents per year. This implies that the cost of avoiding one incident is EUR 550. Even though each individual incident might not be a severe crime, the benefits of using cameras inside stadiums appear to outweigh the costs.

It is tempting to extrapolate these findings to other types of unruly behavior, such as crimes on the streets, in subways, schools, shops, or apartment complexes. After all, the individuals who are most affected by

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the cameras inside stadiums, typically relatively young men, are potentially unruly elsewhere. I have argued that cameras might have similar effects in other well-contained environments when coverage is high and signs are visible, such as in public transportation systems and parking lots. Additional empirical research, which addresses the particular problems inherent in this approach, would certainly help policy-makers to evaluate whether the potential positive effects of cameras outweigh the costs.

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