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THE EFFECTS OF SURVEILLANCE CAMERAS ON CRIME: EVIDENCE FROM THE STOCKHOLM SUBWAY*

Mikael Priks

I study the effects of surveillance cameras on crime in the Stockholm subway system. Beginning in 2006, surveillance cameras were installed in subway stations at different points in time. Difference-in-difference analysis reveals that introduction of the cameras reduced crime by approximately 25% at stations in the city centre. The types of crimes deterred by cameras are planned crime, that is, pickpocketing and robbery. It is also shown that some of the crimes were displaced to surrounding areas. The cost of preventing one crime by the use of surveillance cameras is approximately US$ 2,000.

Surveillance cameras have become a common method to combat crime. In the UK alone, an estimated 4 million cameras have been installed (Associated Press, 2007). There is a major concern, however, regarding their intrusion upon privacy. To motivate the use of surveillance cameras, it is therefore important to begin by carefully studying the extent to which cameras deter crime.

Here, I exploit the fact that surveillance cameras were introduced in the Stockholm subway system at different points in time during the period 2006–8. Surveillance cameras were found to reduce the overall crime rate by approximately 25% at stations in the city centre. Such a station recorded on average approximately 11 crimes per month before introduction of the cameras. The reduction therefore amounts to almost three fewer crimes per station and month. The effect was immediate, which indicates that it was due to deterrence, and lasting. The analysis also shows that the cameras did not deter crime in the periphery.

I also had access to data on crime in the areas adjacent to the subway stations. The results indicate that 15% of the deterred crimes appear to have been displaced to the area surrounding the stations where cameras were not used.

A cost-benefit analysis reveals that surveillance cameras annually deter approximately 575 crimes, 75 of which are displaced to places nearby, at a cost of US$ 1,000,000. Hence, the cost of preventing one crime is estimated to be approximately US$ 2,000.

In a standard economics model, criminals receive utility from committing a crime and disutility from getting caught, which depends on the monitoring technology as well as the extent to which criminals care about this cost. This implies that some types of crimes should be more sensitive to camera surveillance than others.

Criminals who commit planned crimes, such as professional pickpockets and robbers, are likely to be observant to signs displaying surveillance cameras not only because they tend to be cautious but also because the cameras constitute a large threat

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ex post when victims report a felony. On the other hand, criminals involved in drug-related crimes (drug dealing, possession and use) may be under the influence of drugs and therefore less cautious. In such instances, there are also normally no victims involved who would call for the assistance of camera surveillance in a prosecution. Crimes that are committed in the heat of the moment, such as assault, should also be less sensitive to signs displaying surveillance cameras.

The results are in line with these predictions. Planned types of crime were reduced to a large extent (pickpocketing by 20% and robbery by 60%) but drug-related crime and assaults were unaffected by the cameras. Moreover, 15% of the deterred pickpocketing incidents were displaced to the adjacent area and, as expected, drug-related crime and assaults outside stations were unaffected by the cameras.

Why, then, do cameras tend to deter planned crime in the city but not in the periphery? Since organised gangs prey in stations in the city where there are many victims (pickpocketing constitutes 16% of crime at city stations and only 8% elsewhere), deterrent effects there are to be expected. Moreover, since guards and police officers patrol closer to the stations in the city as compared to the suburbs, cameras should be relatively efficient in the city in the sense that law enforcement officials can use them for a rapid response by guards and police. In the suburbs, this process takes more time, so that criminals have more leeway to escape. I am not able to discriminate between these two different hypotheses, however.

A few studies have examined the effects of cameras in subway stations; see Burrows (1980), Webb and Laycock (1992), and Grandmaison and Tremblay (1997). However, in the first two studies, the installation of cameras was accompanied by other interventions, such as passenger alarms and mirrors, and in the last two there were no signs to signal the presence of cameras. Grandmaison and Tremblay (1997) study a pilot project in Montreal where 13 out of 54 subway stations were selected for the project. This selection was not random and large stations with considerable crime were overrepresented. Apart from Webb and Laycock (1992), who show a temporary effect of cameras on robbery, this literature does not find that cameras have any deterrent effects.

Another aspect of the literature examines the effects of surveillance cameras on crime in more general terms. King *et al.* (2008) evaluate a programme where surveillance cameras were introduced on the streets in San Francisco. Interestingly, they too find that the cameras reduced property crimes by approximately 20% and that violent crime was unaffected by the introduction of cameras. Priks (2014) shows that surveillance cameras reduce unruly behaviour inside soccer stadiums. Welsh and Farrington (2003), and Welsh and Farrington (2009) report evidence from a number of studies analysing the effects of cameras on street crime, burglary and auto theft in public areas. These latter studies use before-and-after measures of crime and mostly comparable control areas but they tend to suffer from the fact that either the installation of surveillance cameras was potentially endogenous to previous crime,[1] or that several types of interventions were introduced simultaneously, or both. Setting the identification problems aside, the

[1] For example, if surveillance cameras are installed due to an increased level of crime, then individuals potentially subject to crime may change their behaviour due to the elevated crime level rather than to the cameras.

overall result from this literature indicates that cameras deter property crime in parking lots only.[2] This literature also reveals no or small displacement effects (Welsh and Farrington, 2003; Gill and Spriggs, 2005; Waples *et al.*, 2009).[3]

In this article, I used placebo treatments for the time periods before the cameras were installed and found no evidence of significant changes in crime prior to the installation of cameras. This, in combination with the fact that the introduction of surveillance cameras was the only policy intervention, allows me to address the deterrent effect of the cameras.

The outline is as follows. Section 1 describes the data. Section 2 reports the empirical strategy and results. Section 3 analyses displacement effects. Section 4 provides a discussion.

1. Data

The dates of installation of the cameras were obtained from the Stockholm Public Transit Authority (Storstockholms Lokaltrafik (SL)). SL is owned by the Stockholm County Council. It operates parts of the public transport system in Stockholm County and is responsible for selling the rights for private firms to operate other parts of the system, such as the subway network. Prior to 2006, there were no surveillance cameras in the subway stations. Towards the end of 2006 and continuing through 2007 and 2008, SL installed surveillance cameras in all of the stations. According to Swedish law, the use of surveillance cameras has to be clearly indicated. Signs are displayed at the entrances to every subway stations as well as on the platforms, next to the signs displaying the direction of the trains.

SL operates a call centre where passengers and the public can phone in and provide information about ongoing crime. This centre, which was already in place prior to introduction of the cameras, is manned by three officers at all times. Following a phone call, the officers can use the cameras in real time to order guards to the crime scenes.

According to the employees at SL in charge of the operation, there was no concurrent joint project and the introduction of cameras was not prompted by a rise in crime.[4] The main purpose was instead to increase the passengers' perception of safety partly by enhancing fire safety.[5] The installations therefore began in some

[2] A notable example of an extensive study is Gill and Spriggs (2005) who analyse the effect of 13 camera projects in England in a wide range of environments where the introduction was not random. They conclude that 'Even when changes /in crime/ have been noted, with the exception of those relating to car parks, very few are larger than could be due to chance alone and all could in fact represent either chance variation or confounding factors' (Gill and Spriggs, 2005, p. 43).

[3] The article is also related to the recent economics literature, which addresses the causal relationship between policing and crime by using instruments (Levitt, 1997) or natural experiments (Di Tella and Schargrodsky, 2004; Klick and Tabarrok, 2005; Poutvaara and Priks, 2009; Machin and Marie, 2010; Draca *et al.*, 2011). Moreover, for a discussion of the effect of surveillance cameras on terrorism, see Stutzer and Zehnder (2013) and references therein.

[4] There was, however, ongoing work to replace turnstiles. But according to Helena Nylén, the employee in charge of this project, to the extent new turnstiles were introduced during the time period under study, they were independent of the installation of surveillance cameras.

[5] The information is obtained from e-mail correspondance with Lennart Argin in 2008 and telephone calls with Mats Lönn and Jan Ekström in February 2013.

underground stations with only one exit. After this was completed, SL did not request any particular order. However, the order of introduction was to some extent influenced by the exogenous circumstance that the application time for permits to use cameras varied (from 48 to 184 days).

A potential concern might be that the order of the introduction was somehow released in the media and that criminals could thereby take extra precautions in advance. But according to the employee in charge of the installations, Mats Lönn, the list was secret except for some suppliers of goods that were informed. Another aspect is that criminals could observe employees as they installed the cameras. But this process only took between a few days and, in rare cases, a couple of weeks, so it should not substantially influence the analysis.

I used daily data from January 1, 2004 to December 31, 2009. I had access to the exact dates of installation in all 100 stations, apart from the two suburb stations Gubbängen and Axelsberg and the city station Östermalmstorg, which I therefore excluded.

Figure 1 is a map of the Stockholm subway system. As in many other cities, it is characterised by some very large stations in the city centre, which serve as nodes for several lines, and many much smaller stations in the suburbs which are served by only one line. The branches of all three lines pass through the central station, T-Centralen, which is by far the largest station both in terms of crime and the number of passengers. I define stations within the major junctions Fridhemsplan, Östermalmstorg, Gullmarsplan and Liljeholmen as city stations.[6]

Figure 2 illustrates the distribution of the timing for introduction of the cameras. It shows that surveillance cameras tended to be installed somewhat earlier in the city as compared to the suburbs. On the other hand, the largest station (T-Centralen) was not among the early stations (cameras were installed in February 2007) and the third largest station in terms of number of passengers (Fridhemsplan) had cameras installed as late as January 2008.

Data on crime were obtained from the Swedish National Police Force and refer to all crimes filed containing words related to 'subway station' during the period under study. I have coded crimes that according to the police took place outside the entrances separately. To do this consistently, I scrutinised the data set manually and coded the observations as taking place outside the station if one of the following words were included: outside, parking lot, bicycle stand, close to, next to, by, and bus stop or if it was otherwise clear that the crime took place in the vicinity of the station. Apart from isolating the effect inside stations, this allows me to study displacement effects.

The types of crime are coded in a very detailed way. The data set obtained covers 258 types of crime in the subway stations. When grouped together into categories, the most common types of crime in the subway are drug-related incidents (17%), assault (16%), pickpocketing (12%) and violence against officials (12%).[7]

[6] The stations Tekniska Högskolan and Stadion are relatively centrally located and also relatively large. They are nevertheless defined as non-city stations because they are located outside the major junction Östermalmstorg. Defining these two stations as city stations does not affect the results qualitatively.

[7] A common type of vandalism, graffiti, is excluded from the data set. At the end of the time period under study, the police began to include it in a data base, which increased the number of reported crimes dramatically.

Fig. 1. *The Stockholm Subway System*

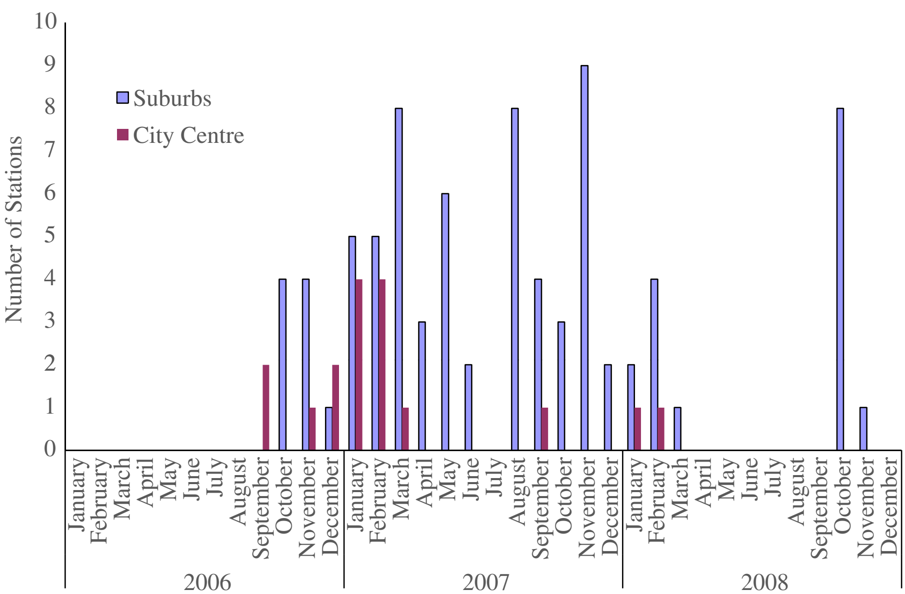

Fig. 2. *Timing of the Installation of Surveillance Cameras*

Table 1 shows the summary statistics for crime in the city centre and outside the city centre as well as crime inside and outside the stations and the number of passengers.

Figure 3 plots crime in 2004 and month of installation in the city centre (starting in September 2006). In line with the information provided by SL officials, there is no correlation between installation time and high-crime stations.

Figure 4 shows the overall level of crime per day in the subway stations on a monthly basis. According to statistics from SL, the number of passengers declines during the summer. There are 15% fewer passengers as compared to the average in June, 30%

Table 1

Summary Statistics

	Mean	SD	Minimum	Maximum	Number of observations
Crime if city = 1 and camera = 0	0.37	1.14	0	29	19,709
Crime if city = 1 and camera = 1	0.37	1.21	0	25	17,555
Crime if city = 0 and camera = 0	0.06	0.39	0	22	104,856
Crime if city = 0 and camera = 1	0.09	0.52	0	16	70,504
Passengers if city = 1 and camera = 0	31,904	33,864	6,000	155,000	19,709
Passengers if city = 1 and camera = 1	32,390	35,903	6,000	163,900	17,555
Passengers if city = 0 and camera = 0	5,360	3,662	1,000	21,000	104,856
Passengers if city = 0 and camera = 1	6,025	4,079	1,000	25,200	70,504
Crime per passenger if city = 1 and camera = 0	0.11	0.48	0	29	19,709
Crime per passenger if city = 1 and camera = 1	0.13	0.57	0	22	17,555
Crime per passenger if city = 0 and camera = 0	0.13	0.93	0	54	104,856
Crime per passenger if city = 0 and camera = 1	0.17	1.18	0	48	70,504
Pickpocketing per passenger if city = 1 and camera = 0	0.017	0.093	0	1.65	19,709
Pickpocketing per passenger if city = 1 and camera = 1	0.013	0.091	0	2.77	17,555
Pickpocketing per passenger if city = 0 and camera = 0	0.009	0.147	0	9.23	104,856
Pickpocketing per passenger if city = 0 and camera = 1	0.011	0.168	0	9.60	70,504
Crime per passenger outside stations if city = 1 and camera = 0	0.003	0.054	0	2.77	19,709
Crime per passenger outside stations if city = 1 and camera = 1	0.003	0.061	0	3.29	17,555
Crime per passenger outside stations if city = 0 and camera = 0	0.009	0.210	0	16.22	96,364
Crime per passenger outside stations if city = 0 and camera = 1	0.005	0.140	0	9.88	63,652

Notes. The unit of analysis is days for crime and years for passengers. Crime per passenger and pickpocketing per passenger are multiplied by 10,000.

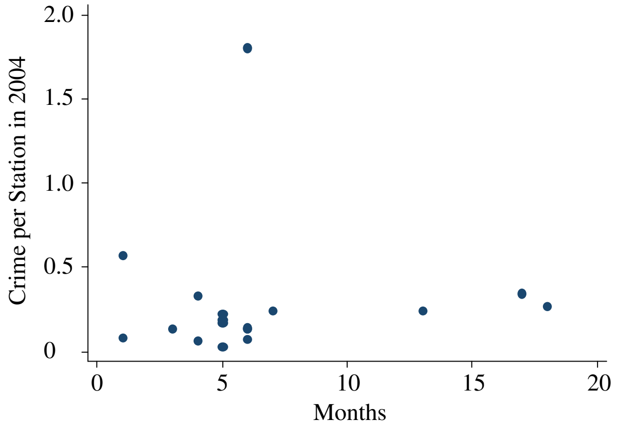

Fig. 3. *Crime in 2004 and Dates of Installation in the City*
Note. The outlier is the central station where more crimes are committed compared to the other stations in the city.

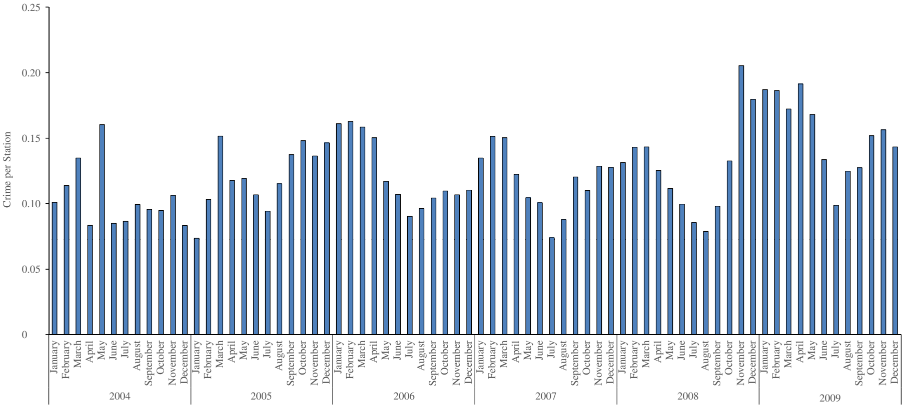

Fig. 4. *Crime in the Stockholm Subway*

fewer passengers in July, and 20% fewer passengers in August. The Figure shows a pattern whereby crime follows these fluctuations. The crime level is quite low in the summer, particularly in July. There is also an increase in crime towards the end of 2008.

2. Method and Results

I began by estimating the effects of cameras in the subway system as a whole and then in the city separately. Let Y_{it} denote the number of reported crimes per passenger at station i in period t, where days is used as the unit of analysis.[8] I ran the following OLS regression:

[8] I use crime divided by the average number of passengers per station to ensure that it is not changes in the number of passenger that drive the results. Dividing crime by passenger per year yields similar results. The results are also similar, albeit somewhat smaller, when crime is used as dependent variable.

$$Y_{it} = \alpha_i + \beta \text{camera}_{it} + \theta_t + \omega_{it} + v_{it}, \tag{1}$$

where α_i is a station fixed effect. Camera equals 1 for days when cameras were installed and 0 otherwise. Parameter β measures the effect of having cameras in the areas studied (the whole subway system or in the city). Parameter θ_t denotes time-specific (year or day by year) fixed effects in period t. This is a difference-in-difference design that allows me to identify the effects of cameras on crime. In some specifications, I also allow for station-specific linear trends ω_{it}. Adding these trends is essentially a type of regression discontinuity design, with time as the 'running variable', which allows a study of the jump at the time of introduction of cameras. In the baseline specifications, all stations are equally accounted for independently of their size. In some specifications, I weighted the observations by the number of passengers per station.[9] Standard errors are clustered by the station in all specifications.

I also ran the following OLS equation using the whole data set assuming that time trends in the city and outside the city were the same:

$$Y_{it} = \alpha_i + \beta \text{camera}_{it} + \gamma \text{camera}_{it} \times \text{city}_t + \theta_t + \omega_{it} + v_{it}. \tag{2}$$

City equals 1 if the station is defined as located in the city and 0 otherwise. Parameter β measures the effect of having cameras at the 80 stations that are not included in the city sample. $\beta + \gamma$ measures the effect of surveillance cameras on crime at the 17 stations included in the city sample.

In order to study trends, the break at the time of introduction and possible dynamic effects, I also performed an event time study where I ran a similar regression as in (1) except that camera$_{it}$ was divided into monthly event time dummy variables $\sum_{\tau=-T}^{T} \beta_\tau \text{camera}_{i\tau}$. The event time indicator variables track the month when cameras were introduced in one of the stations and the months prior and subsequent to the introduction.

Table 2 reports the main results. Columns 1 and 2 show that there is no general effect of surveillance cameras on crime in the subway system as a whole. Columns 3–6 present the results from regressions where the sample is the city centre. Column 3 reports the results with year fixed effects and the other columns day by year fixed effects. Column 5 reports the results when station-specific linear trends are added and in Column 6 the observations are weighted by the number of passengers per station. The estimated effect of the cameras on crime in the city is large and highly significant in all specifications. Column 7 reports results from an interaction model where the whole data set is included. Column 8 reports results from the same regression with station-specific trends. The F-test of the joint significance of the variable camera and the interaction variable camera × city shows that the result is significant in both specifications.[10] The average number of crimes per day and passenger (multiplied by 10,000) before the introduction was 0.11. Using the identical estimated effects from the specifications in

[9] If the effect of surveillance cameras is homogeneous across stations, then the weighting should not matter for the coefficients. However, I also use weighted regressions, which measure the probability for a passenger to be a victim of crime, since it is possible that the effects differ across stations.

[10] Clustering on stations should alleviate the issue of serial correlation. However, as a further robustness check, I collapsed the data into months and weeks, which did not alter the results.

Table 2

Surveillance Cameras and Crime in the Subway

Dependent variable: crime/passenger								
Sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Camera	−0.006	0.003	−0.034**	−0.029**	−0.029**	−0.015*	0.013	0.022
	(0.010)	(0.013)	(0.012)	(0.011)	(0.012)	(0.007)	(0.015)	(0.015)
Camera × city							−0.028*	−0.037***
							(0.016)	(0.012)
Station-specific linear trends	No	No	No	No	Yes	No	No	Yes
Year fixed effects	Yes	No	Yes	No	No	No	No	No
Day by year fixed effects	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Obervations weighted by passengers	No	No	No	No	No	Yes	Yes	Yes
F-test of joint significance of camera and camera × city (p-value in parantheses)							4.34	2.89
							(0.04)	(0.09)
R^2	0.00	0.02	0.01	0.07	0.07	0.08	0.02	0.02
Observations	212,624	212,624	37,264	37,264	37,264	37,264	212,624	212,624

Notes. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level. The regresssions include station fixed effects and the standard errors are clustered at the level of the stations. The specifications in columns 1, 2, 7 and 8 include the whole data set.

columns 4 and 5, −0.029, the introduction of cameras reduced crime in subway stations in the city by approximately 25%. Since an average station in the city had approximately 135 crimes per year before cameras, the reduction amounts to almost 34 crimes per station and year.

Table 3 reports results for planned crimes that involve victims (pickpocketing and robbery). I first used year fixed effects reported in column 1 and then day by year fixed effects. In column 3, the observations are weighted by passengers. Columns 4 and 5 show results from regressions using the full sample. In column 5, station-specific linear trends are also included. All evidence point to the fact that cameras reduce pickpocketing. Using the identical estimates from specifications reported in columns 1, 2 and 3, pickpocketing was reduced by approximately 23% compared to the average of 0.017 without cameras in the city. Specifications 6–10 report the effects on robbery. While robberies are usually very severe, they are also very rare crimes (there are 271 incidents in the city centre sample). This result should therefore be interpreted with considerable caution. When the city centre sample is used, cameras significantly reduced robbery (specifications 6 and 7; specification 8 is significant just below the 10% level). However, the result is not robust to using the interaction model (specifications 9 and 10). The size of the effects varies and amounts to, on average, reductions of approximately 60%.

Table 4 reports regressions from drug-related crime and assaults; apart from the regression reported in column 9, none of the ten specifications in this Table show deterrent effects of cameras. This is not surprising in the sense that potential criminals

Table 3

Surveillance Cameras and Planned Crime with Victims

Dependent variables: columns (1–5) pickpocketing/passenger, columns (6–10) robbery/passenger										
Sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Camera	−0.004*	−0.004	−0.004***	0.001	0.002	−0.002*	−0.003**	−0.001	−0.001	−0.001
	(0.002)	0.002	0.001	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Camera × city				−0.007**	−0.006***				0.000	0.001
				(0.003)	(0.002)				(0.001)	(0.001)
Station-specific linear trends	No	No	No	No	Yes	No	No	No	No	Yes
Year fixed effects	Yes	No	No	No	No	Yes	No	No	No	No
Day by year fixed effects	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Obervations weighted by passengers	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
F-test of joint significance of camera				16.71	13.45				1.00	0.00
and camera × city (p-value in parantheses)				(0.00)	(0.00)				(0.32)	(0.95)
R^2	0.01	0.07	0.09	0.02	0.02	0.00	0.06	0.05	0.01	0.01
Observations	37,264	37,264	37,264	212,624	212,624	37,264	37,264	37,264	212,624	212,624

Notes. ***Indicates significance at the 1% level, ** at the 5% level, and * at the 10% level. The regressions include station fixed effects and standard errors are clustered at the level of the stations. The specifications in columns 1–3 and 6–8 include stations in the city and the specifications in columns 4, 5, 9 and 10 the whole data set.

Table 4

Surveillance Cameras, Drug-related Crime and Assaults

Dependent variables: columns (1–5) drug related crime/passenger, columns (6–10) assault/passenger										
Sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Camera	−0.003	0.001	0.004	0.004	0.005	−0.004	−0.004	−0.002	−0.001	−0.002
	(0.005)	(0.005)	(0.004)	(0.005)	(0.006)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
Camera × city				−0.004	0.002				−0.003	0.000
				(0.007)	(0.006)				(0.003)	(0.003)
Station-specific linear trends	No	No	No	No	Yes	No	No	No	No	Yes
Year fixed effects	Yes	No	No	No	No	Yes	No	No	No	No
Day by year fixed effects	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Obervations weighted by passengers	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
F-test of joint significance of camera and camera × city (p-value in parantheses)				0.00	0.41				3.61	0.84
				(0.96)	(0.52)				(0.06)	(0.36)
R^2	0.01	0.07	0.07	0.02	0.02	0.00	0.07	0.07	0.02	0.02
Observations	37,264	37,264	37,264	212,624	212,624	37,264	37,264	37,264	212,624	212,624

Notes. The regressions include station fixed effects and the standard errors are clustered at the level of the stations. The specifications in columns 1–3 and 6–8 include stations in the city and the specifications in columns 4,5,9 and 10 the whole data set.

may be influenced by drugs and commit crimes in the heat of the moment, which is likely to reduce their awareness of camera signs. Moreover, in the case of drug dealing none of the parties will report the crime so that cameras can be used *ex post*.

To exclude the possibility that the results are not driven by trends, as well as to study the break at the time of introduction and possible dynamic effects, I also performed an event time analysis of the effect of cameras on crime in the city centre. Figure 5 plots month event time coefficients using station and year fixed effects. Event time zero corresponds to the month the policy is introduced in a station. The event time coefficients denote the average number of incidents per passenger in month τ relative to the number of incidents per passenger in the month preceding introduction of cameras. The bars show 95% confidence intervals and standard errors are clustered by station. Prior to the introduction of surveillance cameras, no single month is significantly different from zero. Following the introduction of cameras, there is a reduction in crime per passenger. All the subsequent coefficients lie below the reference group ($t - 1$) and several of the event months are significantly different from zero. Some of the coefficients of the last event months are markedly lower than before. The number of observations falls rapidly in the initial and final periods, which explains the large standard errors. A balanced panel would include 32 event-time dummies in addition to the reference category prior to the introduction and 23 subsequent periods with 510 observations in each period. Such a window highlights the fact that there is an immediate and lasting reduction in crime where ten periods are significantly different from zero subsequent to the introduction.

In a similar robustness test, Table 5 reports several placebo treatments for the time periods prior to introduction of the surveillance cameras. Column 1 reports 12 placebo month prior to the introduction of cameras and column 2 reports 18 placebo months. The placebos are both positive and negative and none of them are significant. The true

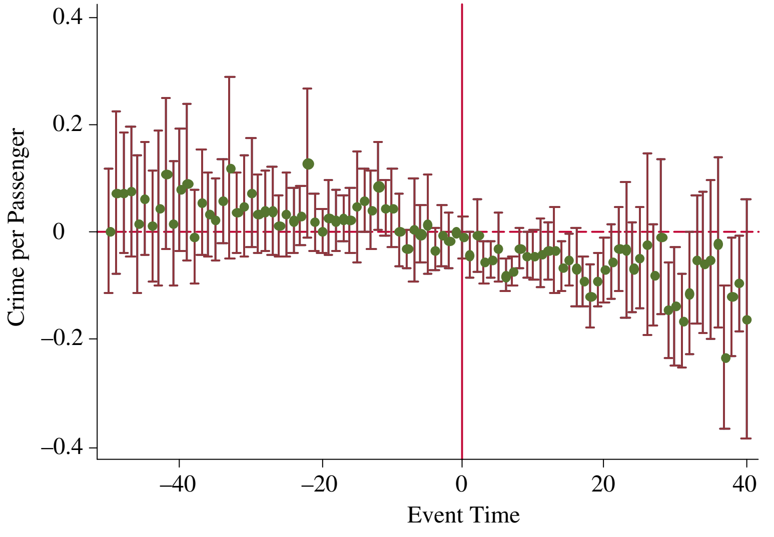

Fig. 5. *Surveillance Cameras and Crime, Monthly Event Time Analysis*

Table 5

Placebo Treatments

Dependent variable: crime/passenger		
Sample	(1)	(2)
Camera	−0.036**	−0.036**
	(0.014)	(0.014)
Camera-1	0.022	0.021
	(0.020)	(0.020)
Camera-2	−0.025	−0.024
	(0.022)	(0.023)
Camera-3	−0.029	0.030
	(0.029)	(0.030)
Camera-4	−0.051	−0.052
	(0.033)	(0.032)
Camera-5	0.027	0.026
	(0.041)	(0.041)
Camera-6	0.001	−0.000
	(0.050)	(0.050)
Camera-7	0.040	0.041
	(0.053)	(0.052)
Camera-8	−0.024	−0.025
	(0.021)	(0.021)
Camera-9	−0.032	−0.032
	(0.022)	(0.023)
Camera-10	0.010	0.011
	(0.032)	(0.032)
Camera-11	−0.029	−0.030
	(0.038)	(0.037)
Camera-12	0.030	0.036
	(0.024)	(0.048)
Camera-13		−0.021
		(0.034)
Camera-14		0.007
		(0.046)
Camera-15		0.036
		(0.033)
Camera-16		−0.022
		(0.025)
Camera-17		0.003
		(0.025)
Camera-18		−0.015
		(0.023)
R^2	0.07	0.07
Observations	37,264	37,264

Notes. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. The regressions include day by year fixed effects and station fixed effects. The standard errors are clustered at the level of the stations.

camera dummy is highly significant in both specifications. This indicates that the introduction of cameras was exogenous to previous crime.

In sum, the evidence indicates that surveillance cameras indeed reduce crime in stations in the city centre. The effects seem to be due to deterrence as opposed to incapacitation as crime was immediately reduced subsequent to the introduction of cameras. Moreover, pickpocketing is the most common crime to be reduced by cameras and since the penalties for this type of crime are often fines, this also suggests that the effects observed are in fact due to deterrence.

3. Displacement Effects

The displacement effect may be addressed by using data on crime adjacent to the subway stations, that is, where camera surveillance is not permitted. I also had access to data on crimes that took place just outside the subway stations, which include bus stops, parking lots or parking stands for bicycles. According to the regressions weighted by the number of passengers in Table 6 (columns 3–5), some of the deterred pickpocketing incidents inside stations were displaced to the area outside the stations. Relative to the average before cameras were installed, pickpocketing adjacent to the stations increased by approximately 300%, or 12 incidents per year.[11] Table 7 shows that when weighting the observations by the number of passengers, there is also a significant increase in crime per passenger just outside the stations in the central city following the introduction of cameras inside the stations. The increase was also very large, 130%. The average number of crimes just outside stations per station and year were approximately three. Based on the estimated 130% increase, the introduction of surveillance cameras leads to a displacement effect amounting to four crimes per station and year. Note that the coefficients in the weighted regressions in Tables 6 and 7 are somewhat larger and the precision is better than in the non-weighted regressions. The unweighted regression on total crime in the city centre sample, for example, is not significant (column 2 in Table 7). On the other hand, the unweighted regression on pickpocketing reported in column 2 in Table 6 is significant at the 11% level.[12]

Table 6

Surveillance Cameras and Pickpocketing Outside the Subway

Dependent variable: pickpocketing /passenger					
Sample	(1)	(2)	(3)	(4)	(5)
Camera	0.003	0.004	0.007***	0.005***	0.003*
	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)
Camera × city				0.000	0.002
				(0.001)	(0.003)
Station-specific trends	No	No	No	No	Yes
Year fixed effects	Yes	No	No	No	No
Day by year fixed effects	No	Yes	Yes	Yes	Yes
Obervations weighted by passengers	No	No	Yes	Yes	Yes
F-test of joint significance of camera				7.37	4.76
and camera × city (p-value in parantheses)				(0.01)	(0.03)
R^2	0.00	0.06	0.08	0.01	0.01
Observations	37,264	37,264	37,264	197,280	197,280

Notes. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. The regressions include station fixed effects and the standard errors are clustered at the level of the stations. The specifications in columns 1–3 include stations in the city and the specifications in columns 4 and 5 the whole data set. Pickpocketing/passenger is multiplied by 100,000.

[11] Robberies per passenger also tend to increase significantly but there were only 15 incidents in the city centre before cameras. Analysing the effects on drug-related crimes and assaults outside city centre stations provides a falsification test, as these types of crimes were not deterred by cameras. As expected, drug-related crimes and assaults outside stations were not affected by the introduction of cameras.

[12] Moreover, the results of the interaction models without weights show significant results even though the size of the effects somewhat changes.

Table 7

Surveillance Cameras and Crime Outside the Subway

Dependent variable: crime/passenger					
Sample	(1)	(2)	(3)	(4)	(5)
Camera	0.001	0.001	0.004**	0.000	−0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Camera × city				0.002***	0.005**
				(0.001)	(0.002)
Station-specific linear trends	No	No	No	No	Yes
Year fixed effects	Yes	No	No	No	No
Day by year fixed effects	No	Yes	Yes	Yes	Yes
Obervations weighted by passengers	No	No	Yes	Yes	Yes
F-test of joint significance of camera and camera × city (p-value in parantheses)				3.88	9.84
				(0.05)	(0.00)
R^2	0.01	0.07	0.07	0.01	0.01
Observations	37,264	37,264	37,264	197,280	197,280

Notes. ***denotes significance at the 1% level, **at the 5% level and *at the 10% level. The regresssions include station fixed effects and the standard errors are clustered at the level of the stations. The specifications in columns 1–3 include stations in the city centre and the specifications in columns 4 and 5 include the whole data set.

However, since there are only 1,003 reported incidents in this data set, these results should be interpreted with considerable caution. Nevertheless, they indicate that some of the reduction in crime inside the stations in the city was displaced to the area adjacent to the stations.

4. Discussion

Firms and governments in many countries increasingly use surveillance cameras in order to reduce crime. However, the potentially deterrent effects of such cameras are not yet well understood. In a natural experiment from the Stockholm subway system, surveillance cameras were found to reduce crime by approximately 25% at the stations in the city centre, 15% of which was displaced to the vicinity.

In order to determine whether cameras should be used or not, it is also necessary to take the cost of the cameras into account. According to SL, the total costs of its cameras and the auxiliary equipment is SEK 33 million (approximately US$ 5 million), and the cameras have to be replaced every fifth year. SL's call centre had the same number of employees (15) before and after introduction of the cameras, so employee costs have not changed. I have estimated that cameras deter approximately 575 crimes per year at the subway stations. On the other hand, approximately 75 crimes were displaced to non-surveilled areas adjacent to the stations. Therefore, in total, assuming that there is no other displacement effect, there were 500 fewer crimes due to the cameras. Assuming also that there are no costs of intrusion on privacy, the cost of reducing one crime is just over SEK 13,000 (approximately US$ 2,000).

It should be noted that this article deals with the deterrent effects of the cameras. However, surveillance cameras are sometimes used to gather evidence which, of course, is an additional benefit.

It is difficult to estimate the value of a crime that did not take place. Obviously, an individual who is subject to a crime incurs substantial costs. More generally, reduced crime rates enhance a feeling of safety among passengers. SL carries out annual surveys where passengers are asked about their satisfaction with SL. One part of this survey pertains to passenger' perception of their own safety. In the 2009 survey, it was reported that women travelling alone in the evening and at night felt 11% more safe in 2009 as compared to 2006 (AB SL Marknadsanalys, 2009). Of course, it is not clear whether this change is due to the introduction of cameras. Nevertheless, it may indicate that cameras increase passengers' perception of safety which, after all, is the reason why they were installed in the first place. In sum, the benefit of surveillance cameras may therefore be higher than SEK 13,000. Under the assumption that crime is only displaced to areas adjacent to the subway stations, my policy conclusion is that the benefits of using cameras at subway stations in the city may outweigh the costs. This is in line with the few existing cost–benefit analyses in this area (Skinns, 1998; Gill and Spriggs, 2005).

Finally, this analysis does not allow me to say what might have happened if cameras had been installed solely at the city stations. But since the cameras seem to be more efficient in the city centre, this could indicate that it is cost-efficient to use cameras in the city centre only.

Criminals who roam the subways in different countries are likely to be affected in similar ways by the presence of surveillance cameras. In fact, according to the Swedish police, pickpocketing is often committed by international gangs travelling around from one country to another.[13] Thus, the results may also provide an indication of the effectiveness of cameras outside Sweden. Needless to say, more studies using exogenous variation and isolated policy intervention would certainly help policy makers when deciding whether surveillance cameras should be used or not.

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Additional Supporting Information may be found in the online version of this article:

Data S1.

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