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The Effectiveness of an Electronic Security Management System in a Privately Owned Apartment Complex

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Poisson and negative binomial regression methods are used to analyze the monthly time series data to determine the effects of introducing an integrated security management system including closed-circuit television (CCTV), door alarm monitoring, proximity card access, and emergency call boxes to a large privately-owned complex of apartment buildings in New York City. Crime rates in a control apartment complex under the same ownership, and in the police precinct in which the 2 complexes are located, serve as controls.

Keywords: *CCTV; Poisson; negative binomial; crime rates; interrupted time series; Peter Cooper Village; Stuyvesant Town*

Introduction

For several decades, strategies for preventing crime through modification of the physical environment have been advocated, and in some places, implemented (Jeffery 1971; Newman 1972; Clarke 1992; Robinson 1999;

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Crowe 2000). One of them, electronic surveillance, is now being adopted widely in the United Kingdom, and on a more limited basis (so far), in continental Europe, Canada, Australia, New Zealand, South Africa, the United States, China, Japan, and the Middle East, in both public and private spaces, for the purpose of preventing or deterring crime without erecting unsightly physical barriers such as walls or barbed wire fences or deploying conspicuous, intimidating police officers, and security guards (Wilson and Sutton 2003a, 3; Norris, McCahill and Wood 2004).

Electronic surveillance is thought to offer the possibility of reducing crime in an area in several ways. By raising the likelihood that a law violator will be apprehended and punished, it may discourage prospective criminals. Electronic surveillance may also facilitate an arrest and conviction following the commission of a crime, thereby removing an offender from the area. Insofar as criminals do not restrict their crimes to 1 specific area, these arrests and convictions may reduce crime even in areas not under surveillance. The visible presence of surveillance equipment could also remind those in the area that crime is a possibility, thereby inducing them to take precautions against being victimized by violence or theft. On the other hand, some residents and passersby may believe that the presence of surveillance equipment deters crime effectively, and consequently let their guards down. If that happens, surveillance equipment could increase crime, or at least fail to reduce it. It should be kept in mind, of course, that many crimes do not take place in public. A substantial fraction of homicides and assaults occur indoors, between intimates or associates. One would not expect surveillance cameras in public spaces to do much to stop these crimes.

Despite uncertainties regarding its effectiveness, surveillance equipment is being introduced in the American cities at a rapid pace. As recently as 1997, only 13 police departments in the United States used closed-circuit television (CCTV) cameras, primarily to observe traffic conditions (Nieto, Johnston-Dodds, and Simmons 2002). Just 2 years later, there were 769 surveillance cameras in downtown Manhattan and Harlem alone; by 2006 there were 4,468, almost 6 times as many. Most of the cameras were installed by private businesses (Gendar 2006). New York's Mayor Michael Bloomberg has announced his intention of following London's lead by increasing the number of city-operated cameras (Goldsmith 2007). In mid-2007, the New York Police Department (NYPD) revealed a plan to detect terrorists by setting up a Web consisting of 100 additional cameras and road blocks in lower Manhattan (Buckley 2007). A more recent proposal of the NYPD calls for the installation of 3,000 public and private cameras in Lower Manhattan as part of a larger security program (Baker 2008). In addition, the Metropolitan Transit Authority is installing 400 cameras in city busses and subway stations. The Parks Department has announced plans to follow suit (Calder 2008).

New York City is by no means the only American city to adopt CCTV. The City of Chicago has announced plans to deploy surveillance cameras on a large scale (Kinzer 2004). Throughout the United States, CCTV is being installed in public places, in schools, mass transit stations, businesses and apartment complexes (Nieto, Johnston-Dodds, and Simmons 2002). Most law enforcement agencies make use of them (International Association of Chiefs of Police 2001). According to 1 recent tally, more than a million CCTV cameras are now in use in the United States (Nestel 2006), with the number rapidly increasing. This is still far less than the 5 million cameras estimated to be operating in the United Kingdom, whose population is approximately one fifth of the American population.[1]

Electronic surveillance has been challenged as an unwarranted invasion of privacy, and conceptualized as 1 component of a new social control strategy involving the diffusion of the "gaze" from the panopticon prison to public spaces (Lyon 1994; Painter and Tilley 1999; Koskela 2003; Vaz and Bruno 2003; Yar 2003; Fussey 2004; Monahan 2006; Norris and McCahill 2006; Taylor 2007). Its effectiveness in preventing crime has been the subject of both research and debate. In response to concerns about privacy and effectiveness, the Washington, DC, Council recently voted to withhold US$900,000 in proposed funding for consolidating the operations of 5,200 city surveillance cameras until further efficacy studies are performed (Lipowitz 2008). The present study contributes to our understanding of CCTV's effectiveness in 1 setting—a privately owned, middle-income apartment complex located in a large American city—New York.

Literature Review

The United Kingdom embraced CCTV technology as a surveillance system many years before the United States, and it has been more widely adopted there. As a result, there is a much larger body of knowledge assessing the extent to which the introduction of electronic surveillance in a particular place reduces crime for the United Kingdom than there is for the United States. In our search for the evaluation studies, we located more than a dozen for the United Kingdom (summarized in Armitage 2002), but a mere handful for the United States. This paucity of American studies has also been noted in other surveys of the field (Nieto, Johnston-Dodds, and Simmons 2002). Surveying the British studies dealing with city centers and public housing, public transportation, and automobile parking lots, Welsh and Farrington (2002, 2003) concluded that the effects of electronic surveillance on violent and property crime were mixed. Some of the studies produced evidence for crime prevention, crime displacement to neighboring areas, and diffusion of benefits to abutting districts, i.e., reductions of crime beyond the places directly targeted (Clarke and Weisburd 1994; Skinns 1998).

Methodological limitations make it difficult to draw definitive conclusions from much of this research (Armitage 2002). Many tracked crime over short spans of time, so that estimates of effects were imprecise. Quite a few of the studies failed to use distinct experimental and control areas for comparison purposes. In this circumstance, a comparison of crime rates before and after the introduction of CCTV in an experimental site alone fails to control for trends that may be unrelated to the introduction of electronic surveillance. Comparison of crime rates in experimental and control groups following the introduction of surveillance, with no measure of crime rates at earlier times, fails to take into account the possibility that any observed differences predated the introduction of surveillance. In addition, some of the studies failed to take the seasonal variation in crime rates into account.

A more recent survey of the 13 British studies meeting minimal standards of methodological rigor found the results consistent with the absence of any effect in each of the locations studied. A meta-analysis in which data from all the 13 studies were pooled again found no statistically significant evidence that CCTV reduced crime (Gill and Spriggs 2005).

A new report issued last year by the Home Office concluded that most of the British cameras are badly positioned, produce images of poor quality, and are used primarily to monitor traffic or to observe people, rather than to apprehend criminals (Johnston 2007). According to the Detective Chief Inspector Mike Neville of Scotland Yard, they fail to stop crime because many criminals assume that the cameras are not working (Johnston 2008). In London, where there are at least 10,000 cameras, the density of cameras fails to improve the apprehension rate for crimes (Davenport 2008). Although some crimes have been solved through the evidence provided by the CCTV cameras, only 3% of street robberies are solved in this way. In addition, police officers dislike looking through the images because it is "hard work" (Johnston 2008). It appears, then, that electronic surveillance may not be an effective crime prevention strategy, at least not as currently carried out in Great Britain.

Similar conclusions regarding the inefficacy of CCTV in reducing crime, based on much more limited evidence, have come from Scotland (Ditton et al. 1999). In Australia, 2 evaluations were carried out, but the failure to collect data on crime rates prior to the introduction of CCTV made it impossible to draw conclusions as to its efficacy (Wilson and Sutton 2003b, 2).

We have been able to locate only 4 evaluations of CCTV as a crime prevention measure in the American settings. In the first to be conducted in the United States, cameras were installed in the lobbies and elevators of 3 buildings containing of 159 apartments and elevators in a New York public housing complex consisting of 26 buildings, and they were monitored by the residents themselves. The cameras broadcast both video and audio into the residents' television sets. Three months after the cameras were installed, the number of crime incidents rose for some categories and dropped for others. In the experimental buildings, the number of crime incidents declined from 32 to 29 (a 9.4% drop), whereas they dropped from 26 to 21 (i.e., by 19.2%) at the control sites. With a drop in the control buildings twice as large as in the experimental buildings, these results do not suggest that CCTV reduces crime (Musheno, Levine, and Palumbo 1978).

In a second study of CCTV in a public housing project, cameras were installed at 9 locations comprising 1,200 apartments in the experimental projects, which were located in Albany, NY, and monitored from a remote location 24 hr a day, 7 days a week, by uniformed police officers. Williamson and McLafferty (2000) evaluated the impact of the CCTV intervention 18 months after the implementation and focused on the crime rates inside the public housing projects and in a radius of 0.1 miles of the property. The housing project that received the intervention did not show any change in the total number of police-recorded crimes, either inside the project or in the immediate proximity, while the total crime in the control project dropped by 5.3% inside the project and by 4.0% in a 0.1 buffer zone. The observed decrease in major felonies occurring in both housing projects appeared to be part of a broader citywide crime drop taking place in New York in the late 1990s. Williamson and McLafferty looked for evidence of displacement and the diffusion of benefits but could find no clear evidence of either.

A third study evaluated the installation of CCTV at 3 sites in Cincinnati (Mazerrolle, Hurley, and Chamlin 2002). All 3 sites were public spaces—a street, a shopping area in a residential neighborhood, and a farmer's market.

The researchers tallied behaviors they defined as prosocial and antisocial (some of which were not criminal, e.g., begging), and they also examined calls for service to the police in the vicinity of the cameras. There were very few calls concerning drugs, violence, or property crimes, so the analysis focused on public disorder complaints, including disorderly conduct, curfew violations, and noise. The statistical analysis presented in the report is not very informative, and its authors have informed us that the data are no longer available for further analysis. The numbers presented in the published report do not suggest that CCTV reduced the frequency of any of the outcome measures.

Our own analysis of the counts Mazerrolle, Hurley, and Chamlin display in their tables 3 and 4, for calls for service and calls regarding disorder, using the Poisson regression technique described below, finds that of the 21 coefficients measuring the effect of introducing CCTV, only 2 were significant, and they were positive (indicating that CCTV increased the crime rate). This number could have easily arisen by chance. Not a single effect showed evidence for a significant reduction. To make sure that the failure to achieve statistical significance was not because of the small number of the counts at each site, we pooled the results of the different sites by summing all the counts. We were still unable to find a significant crime prevention effect of CCTV.

A fourth study examined the town of East Orange, NJ, in which the crime rates at the end of the 20th century were twice as high as the national average. In 2003, police officers were given access to CCTV cameras, up-to-the-second police reports, and electronic listening devices mounted around the city that sent an electronic alert to officers within seconds of a gun shot.

The researchers credit these crime-fighting tools for the reduction of crime by 50% in 3 years. Between 2003 and 2006, murders declined by nearly two thirds, rapes by nearly a third, and robberies by half. Property crimes also declined, with burglaries down by more than half. Auto thefts fell by two thirds (Jones 2007). These results were probably not because of a broader downward trend in crime. In the neighboring city of Newark, murder rates rose, and in nearby Irvington, gang violence was so rampant that the city sought the assistance of New Jersey State Police. This study suggests that under some conditions, electronic surveillance could be effective.

The majority of research publications thus far have not focused on CCTV combined with other prevention methods (i.e., alarm monitoring). This is because other ancillary measures, such as card access, alarm monitoring, and emergency call boxes, which are now being adopted, were not relevant or available to the previous CCTV implementations and studies.

The paucity of research has not inhibited the public officials from pronouncing surveillance cameras to be valuable tools for enhancing public safety. Nor has it slowed their adoption in public housing projects and other settings; in 2002, 3,000 CCTV systems were operating in New York public housing projects (Elliott 2006/2007; Bloomberg 2002). To date, no evaluation of their effectiveness has ever been conducted. Considering the extensive resources now being invested in CCTV, it would be desirable to find out just what effect CCTV actually has on crime.

CCTV in Peter Cooper Village (PCV)

The present study extends the small body of research on the effects of electronic surveillance in an American context, a large, privately owned housing development, Peter Cooper Village/Stuyvsant Town (PCV/ST). The complex, consisting of 110 buildings, is situated in the 13th Police Precinct, a predominantly middle-income neighborhood located in the Manhattan borough of New York City.

The study is designed to ensure that the observed changes do not reflect trends in crime rates already underway in the development prior to the introduction of electronic surveillance. We also consider whether surveillance produces a diffusion of benefits or displaces crime into other areas. Prior to describing our research methods, we describe the housing development and the security system whose effects we are assessing.

Housing Complex and 13th Precinct Settings

PCV contains 2,483 apartments and ST 8,747, for a total of 11,230 apartments. The 13th Precinct is situated between 14th Street and 29th Street on Manhattan's East Side. The west side of the precinct borders the Seventh Avenue and the east extends to the FDR Drive. According to the official New York City Web site (2007), the 13th Precinct has a community population of 84,121 people as tallied by the 2000 Census.

There is no way of knowing exactly how many people live in the PCV/ST complex, but a conservative estimate of 2.5 residents per apartment enumerates to 6,207 residents in PCV and 21,868 residents in ST, 7.4% and

26% of the precinct population, respectively. Combined, PCV/ST comprises approximately one third of the inhabitants of the 13th Precinct.

Prior to the introduction of electronic security, the crime rate in both complexes was already very low, possibly reflecting the class composition of the tenant population and because the PCV/ST management had a Public Safety Department that provided private security 24 hr a day, 7 days a week, year-round. In the precinct as a whole, roughly a thousand offenses were recorded by the NYPD in the 3 years before the introduction of electronic monitoring in PCV. Roughly 25% of these were classified as 1 of the 7 crimes considered "major" according to the New York State reporting system.[2] The other three quarters were considered "minor crimes" and will be referred to as such here. Only a tiny fraction of the crimes recorded by the NYPD occurred in PCV/ST.

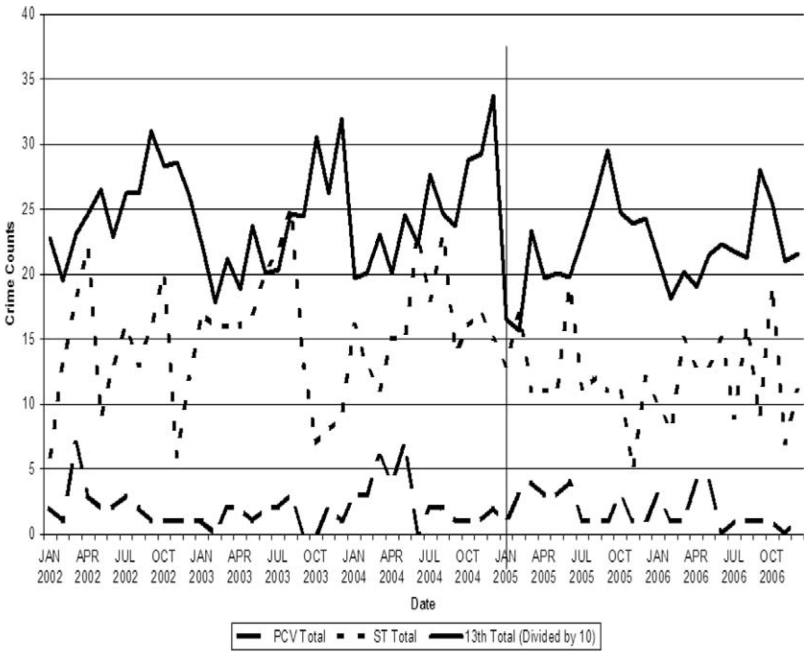
PCV Security System Specifications

At the end of 2004, the PCV management introduced a full electronic Security Management System (SMS) as a "virtual doorman" of sorts at all 21 buildings, both inside and outside, in the PCV property. The management announced that the system was being introduced to enhance security, but leaders of the tenant association, opposing the system, expressed concerns that the system increased surveillance without improving security. According to 1 analyst, commenting on the controversy, "Private landlords of affordable housing often try to convince tenants to submit photos and furnish other identity papers to expose occupants who have subleased apartments illegally" (Amateau 2005).

The SMS consists of electronic key cards and readers, door alarm monitoring, CCTV, interior emergency call boxes, and outside emergency call boxes with attached Pan-Tilt-Zoom (PTZ) cameras. All cameras are connected to the digital video recorders for storage purposes. A total of 198 cameras were installed in PCV: 9 interior cameras per apartment complex and 9 PTZ cameras atop emergency call boxes out-of-doors. This is an integrated system with several components, and for this reason, it could prove more effective than the earlier simpler systems.

As can be seen from Figure 1, which shows total reported crimes for the 2 housing complexes and for the 13th Precinct, crime rates were not rising in either apartment complex prior to the introduction of CCTV. (The counts for the 13th Precinct were divided by 10 so that all the 3 sets of counts could be presented in a single graph with a common scale.) One can readily see

Figure 1
Total Crime Counts in Peter Cooper Village, Stuyvesant Town, and the 13th Precinct



Notes: PCV = Peter Cooper Village; ST = Stuyvesant Town.

the seasonal changes in the precinct crime counts, but the level of crime was not appreciably larger in 2004 than in previous years. The absence of an unusually large surge in crimes just before the introduction of CCTV means that we do not need to be concerned about a regression-to-the-mean effect in our evaluation.

Data and Research Methodology

Information on monthly crime rates was culled from the public safety records management system operated by the management of PCV/ST and from the Compstat program operated by the NYPD's 13th Precinct for the

Table 1
Mean Monthly Crime Counts Before and After CCTV

	PCV		ST		13th Precinct	
Offense	Before*	After**	Before	After	Before	After
Murder	0	0	.08	.04	.18	.38
Rape	0	0	.06	0	1.53	.79
Fel. assault	0	0	0	0	14.00	12.00
Robbery	.06	.13	1.75	1.08	24.39	23.83
Burglary	.08	.08	.33	.46	46.03	35.12
Larceny	.72	.21	5.69	4.42	148.44	139.50
Auto theft	0	.04	.11	.08	13.50	8.46
Assault	0	.08	.72	1.08		
Harassment	.36	.33	1.44	1.46		
Trespass	.08	.38	.61	.67		
Vandalism	.75	.58	4.36	2.75		
All crimes	2.06	1.83	15.17	12.04	246.11	219.75

Notes: CCTV = closed-circuit television; Fel. = felonious; PCV = Peter Cooper Village; ST = Stuyvesant Town.
*36 months of observations.
**24 months of observations.

period from January 1, 2002 through December 2006. Our data thus consist of 60 monthly observations—36 observations for the 3 years prior to the introduction of CCTV at the start of 2005, and 24 observations for the 2 years after the introduction of CCTV. The means and standard deviations for these counts are displayed in Table 1 for each crime category before and after the introduction of CCTV. We use these data to estimate separate models for violent crime offenses (nonnegligent homicide, forcible rape, felonious assault, and robbery), property crimes (burglary, grand larceny auto [GLA], and motor vehicle theft) and minor crimes (nonfelonious assault, harassment, trespassing, and vandalism).

We conduct separate interrupted time series for each crime category and for total crimes, for PCV, ST, and the 13th Precinct. Because PCV and ST are part of the 13th precinct, we subtract the crime counts for the major crimes in PCV and ST (as recorded by the management of PCV/ST) from those for the precinct, before analyzing the precinct data. This is done to ensure that the analysis of precinct data is not contaminated by crimes from PCV/ST.

Earlier analyses of time series data conducted to assess the effect of an intervention on crime rates used Auto-Regressive Integrated Moving

Average (ARIMA) modeling (Glass 1968; Glass, Willson, and Gottman 1975; Heumann and Loftin 1979; McCleary and Hay 1980, 141-203; Loftin and McDowall 1981, 1984; Loftin, Heumann, and McDowall 1983; Singer and McDowall 1988; Mazerolle, Hurley, and Chamlin 2002). This procedure represents crime counts in a particular time span as a linear, additive sum of autoregressive terms (i.e., terms involving lagged crime counts) and moving average terms, representing contemporaneous and lagged shocks. If a significant trend is present in the data, differencing is carried out to achieve stationarity (Box and Jenkins 1976; McCleary and Hay 1980; Yaffee 2000). The intervention being evaluated is represented by a dummy variable equal to 0 for observations prior to the intervention and equal to 1 after it begins. The estimated coefficient for the dummy variable represents the change in the level of the series associated with the intervention.

We do not adopt this strategy here because ARIMA models treat the random shocks as normally distributed. Crime counts can only take on integral values, whereas the normal distribution is continuous. For this reason, ARIMA modeling is based on a technical assumption that is invalid for this type of data. Provided crimes occur at a sufficiently high rate, this technical objection to ARIMA can be disregarded, because in that circumstance the distribution of counts is expected to approximate the normal distribution closely, and the use of ARIMA is harmless, in the sense that it will not lead to a misleading conclusion. However, some of the crimes we are studying occurred infrequently, so that counts for some of the offenses are low. In that circumstance, an ARIMA analysis could be misleading.

Instead of using ARIMA, we adopt a modeling strategy that is more appropriate for count data—Poisson regression and 1 of its relatives—negative binomial regression (Long 1997; Cameron and Trivedi 1998; Long and Freese 2003). We begin by assuming that the crime counts are being generated by a Poisson process at a rate λ. This means that the events occur continuously and independently of one another. In other words, the occurrence of 1 event has no effect on the probability that another event occurs at a later time. The assumption of independence would be violated if criminals, encouraged by a successful crime, committed a new one sooner than they would otherwise have done; or, conversely, if they decided not to press their luck and therefore delayed committing a new crime in the same location. Under the Poisson assumptions, the probability of n events occurring in a time span of duration t is

$$P(n) = \frac{(\lambda t)^n e^{-\lambda t}}{n!}. \tag{1}$$

The influence of independent variables X1 ... Xp on the rate is represented by an exponential function:

$$\lambda = e^{a+b_1x_1+\ldots+b_px_p}, \tag{2}$$

or equivalently,

$$\ln(\lambda) = a + b_1x_1 + \ldots + b_px_p. \tag{3}$$

This choice ensures that no matter what the values of the independent variables, λ will always be nonnegative.

In the short amount of time covered by our time series, there were no major demographic shifts in the population of PCV/ST or the 13th Precinct, so there is no need to introduce characteristics of the population of the precinct or of PCV/ST into the equation as controls. It is well known that crime rates vary seasonally—because of variation in the weather and changes in social life associated with the seasons (e.g., Christmas shopping) (Cohn 1990; Field 1992; Cohn and Rotton 2000; Rotton and Cohn 2000). We accommodate seasonality by introducing a dummy variable for each month except for January, which serves as a reference month. In addition, we introduce a term linear in time, representing trends in crime that might have been taking place irrespective of the introduction of CCTV. This term accommodates possible increases or decreases in crime because of economic, social, or political changes that are not represented explicitly in Equation 2.

We represent the introduction of CCTV with a dummy variable, coded 0 prior to the introduction and 1 afterward. The estimated coefficient for this variable, when exponentiated, represents the increase in the mean rate at which crimes take place. Because adaptation to the presence of cameras should be fairly quick, we assume that the effect of the cameras was felt right away, without an appreciable lag.[3]

For all offenses but one, we predict that the effect of the electronic monitoring system was to suppress crime. Consequently, when we do significance tests for the estimates of the CCTV coefficient, we carry out 1-sided tests. The 1 offense where we make no prediction is trespassing. The reason has to do with the manner in which trespassing incidents came to be recorded. Ever since the introduction of electronic monitoring, when the emergency exit roof door is opened, the command center of the Public Safety Department receives an alert from the electronic monitoring system, and a security officer is dispatched to observe the rooftop in question. That roof-trespassing infractions were taking place prior to the introduction of SMS was well known to the Public Safety Department, which put alarms on the roof doors to detect them. SMS, then, greatly increased the likelihood that a trespassing incident would come to someone's attention and be recorded. Depending on the relative magnitudes of the crime prevention effect and the increased likelihood that an infraction would be recorded, the number of recorded incidents could go up or down.

If displacement of crime from PCV to ST or the 13th Precinct occurred, we would expect the estimates for the CCTV dummy to be positive for these 2 sites, but if a diffusion of benefits occurred, we would find negative estimates. Because of uncertainty as to which effect would be larger, we make no predictions as to the signs of the estimates for these sites and carry out the 2-tailed tests.

Following the estimation of the Poisson regressions,[4] we conducted tests to determine the validity of the assumptions built into the model. To test for the independence of observations, we computed deviance residuals and used them to estimate correlograms. In all but one of the estimations, the correlograms were consistent with the absence of any serial correlations. The 1 exception was trespassing in PCV; there the correlogram suggested some modest serial correlation of errors. For this offense only, we estimated robust (Huber-White) standard errors, which differed only marginally from the original estimates. To determine the adequacy with which the Poisson model fits the observed counts, we conducted deviance goodness of fit tests using the conventional .05 significance level (Cameron and Trivedi 1998, 152-3; Hilbe 2007, 41; Berk and McDonald 2008).

It is a property of the Poisson distribution that the variance of the distribution is equal to the mean. In the Poisson regression model, it is the variance and mean of the distributions, conditional on the predictors, that should be equal. It sometimes happens that a distribution of counts appears to have a variance that is significantly different from the mean. Although underdispersion (an unexpectedly low variance) is possible, overdispersion (a variance that is significantly higher than the mean) is more common.

Where the mean and variance of the distribution are unequal, it is inappropriate to analyze crime counts by assuming a Poisson distribution. Although the estimates obtained from a Poisson regression are consistent in the presence of underdispersion or overdispersion, the standard errors will not be. When significance testing is to be done, underdispersion or overdispersion needs to be taken into account.

We tested the inequality of mean and variance by examining the ratio of the deviance statistic to the degrees of freedom (a ratio substantially larger than 1 points to overdispersion; a ratio less than 1 to underdisperson) and by using the score tests and Lagrange Multiplier tests[5] (Hilbe 2007, 46-9).

When apparent overdispersion is found, it can have a number of causes: outliers, model misspecification (e.g., omission of interaction terms or curvilinearity in the model), heteroskedasticity, outliers, and unmeasured sources of heterogeneity (Cameron and Trivedi 1998; Hilbe 2007; Berk and MacDonald 2008). We examined graphs of the counts and of the residuals against time and found no visible evidence of curvilinearity or pronounced heteroskedasticity. For interaction terms to be present, it would have been necessary for the effect of months to be year dependent, or for the effect of CCTV to be dependent on months or years. We know of no reasons to expect this type of interaction effects, and examination of the same graphs showed no indication of them. There were no conspicuous outliers; in a couple of instances there were 1 or 2 observations that looked marginally like candidates for being considered outliers. Deletion of those cases made little difference to the estimates, so we left them in.

By elimination, where there was evidence of appreciable overdispersion, we attributed it to the omitted sources of heterogeneity, which we introduced into the model by adding a random error term e_i to the right-hand side of Equation 3. We assume that the error terms are well behaved, in particular, that they are homoskedastistic and mutually uncorrelated. However, we do not assume them to be normally distributed. For mathematical convenience, it is commonly assumed that unmeasured heterogeneity follows a gamma distribution. Because the gamma distribution has 2 free parameters, this assumption permits a great deal of flexibility in modeling. The compounding of the gamma with the Poisson distribution leads to a negative binomial distribution for the counts (Greenberg 1979, 270-5; Long 1997; Cameron and Trivedi 1998, 70-7; Hilbe 2007).

For most of the offenses, a Poisson distribution proved to be satisfactory, but for the few for which the score test and Lagrange Multiplier test pointed to overdispersion, we estimated negative binomial regressions. When α, the overdispersion parameter in these estimations, proved to be significantly different from 0 in these estimations, we accepted the negative binomial regression. When it was not significantly different from 0, we adopted the Poisson estimates. In Table 2, all but 2 of the estimates are from Poisson regressions. Because our interest lies in the coefficient representing the intervention, we omit the estimated coefficients for the trend and the monthly dummy variables, and we report only the results for the CCTV dummy in Table 2.

Table 2
Parameter Estimates: Poisson and Negative Binomial Regressions of Crime Counts and CCTV[a]

Offense	PCV	ST	13th Precinct
Murder	—	3.271 (3.135)	−1.068 (1.142)
Rape	—	—	.132 (.485)
Fel. assault	—	—	−.074 (.177)
Robbery	.218 (1.915)	−.006 (.440)	.045 (.107)
Burglary	−.991 (1.784)	−1.722* (.800)	**.143** (.105)
Larceny	−1.444* (.753)	−**.564** (.226)**	−.151* (.063)
Auto theft	—	−.288 (1.650)	−.208 (.174)
Assault	—	.724 (.593)	
Harassment	.648 (.931)	.096 (.440)	
Trespassing	.634 (1.245)	−1.392* (.657)	
Vandalism	−.482 (.626)	−.584* (.269)	
Total	−.197 (.372)	−.416** (.139)	−.075* (.034)

Notes: CCTV = closed-circuit television; Fel. = felonious; PCV = Peter Cooper Village; ST = Stuyvesant Town.
[a] Numbers in parentheses are standard errors; bold-face estimates are from negative binomial regressions. Entries with em dash had no reported crimes or too few to estimate the model.
*$p < .05$, **$p < .005$.

Looking first at the results for PCV, we see that there were too few offenses in the most serious crime categories to carry out an analysis. For the offenses that occurred often enough to permit an analysis, only 1 coefficient achieves statistical significance at the conventional .05 level (larceny, in a 1-tailed test). The coefficient for trespassing is positive, but fails to achieve statistical significance. It could be that the trespassing incidents declined, but chances of detecting an episode increased, but this is just speculation.

When performing multiple significance tests, the chances of achieving a significant finding increase substantially. One way of adjusting to the multiple tests is to use the Bonferonni correction, which divides the nominal significance level (in this case, .05) by the number of tests (in this case, 6). By this criterion, none of our coefficients is significant. Another procedure asks for the probability of obtaining 1 significant coefficient in 6 independent trials, when the probability of obtaining a significant coefficient in 1 trial is .05. Using the binomial formula, that probability is .23. In addition, of the 6 estimates for the CCTV coefficient for the individual offenses, 3 are positive and 3 are negative. This does not suggest a substantial crime reduction effect. Nor does the pattern of positive and negative signs suggest anything about possible effectiveness for some classes of crimes and ineffectiveness for others. In the absence of a strong reason for expecting different signs for different offenses, the estimates for PCV give us little reason to think that the introduction of electronic monitoring reduced crime in PCV.

In neighboring ST, 6 of the 9 coefficients for CCTV are negative (the only exceptions being murder, assault, and harassment). Of the 6 coefficients, 4 are statistically significant at the .05 level. This might suggest that the introduction of electronic monitoring reduced crime in ST. Before interpreting these estimates, we must again consider that we have conducted 9 tests. By the Bonferonni criterion, 1 of these—the coefficient for larceny—is still significant.

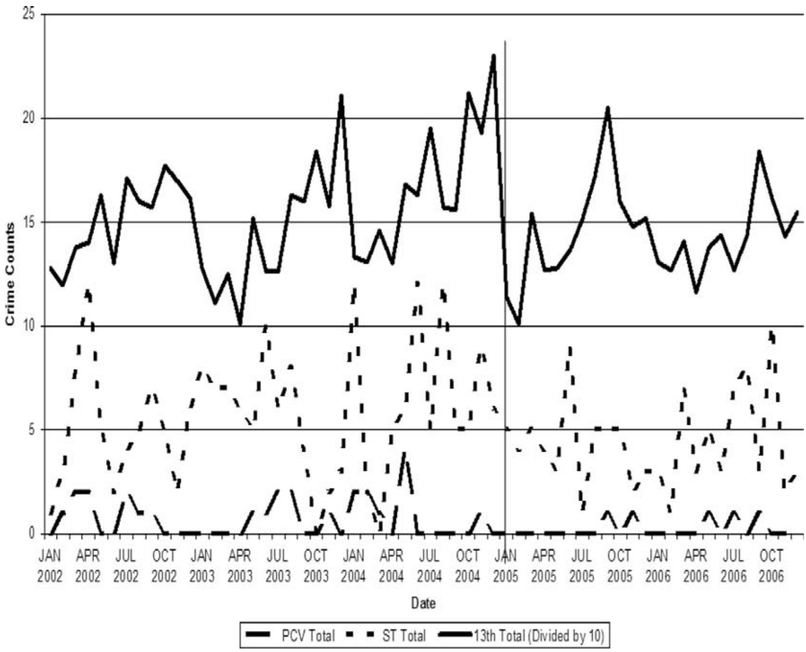
The binomial formula tells us that the chances of obtaining 4 or more significant coefficients by chance when none of the coefficients actually differs from 0 is approximately .0187. This is smaller than .05, and suggests that some (though not necessarily all) of the negative coefficients for ST represents genuine reductions.

Another way of addressing the issue of multiple tests is to note that in a world in which CCTV had absolutely no effect whatsoever, we would expect to find approximately 1 significant coefficient in 20 trials, but we found 4 in 9 trials. For some of the offenses, the reductions in percentage terms were appreciable. Considering just the estimates with negative signs, the coefficients for ST in Table 2 translate into reductions by a factor of .18 for burglary, of .57 for larceny, of .75 for auto theft, of .25 for trespassing, and of .56 for vandalism. One should keep in mind, of course, that the rates for most of these offenses were already quite low before the introduction of electronic monitoring.

Further evidence regarding the ST estimates comes from their timing. For larceny, the drop in crime rates occurred right at the time electronic monitoring was introduced; this was also true of the drop in larcenies in PCV (see Figure 2). However, this was not true for the other significant offenses. On this basis, we conclude that CCTV probably brought about some reduction in larcenies in ST, while the drops in the other offense categories may have been, at least in part, because of other factors that reduced crime in 2005 and 2006.

In the 13th precinct, just 1 of the 6 independent coefficients (the coefficient for larceny) is statistically significant, with a probability of less than .001. This is significant even under the Bonferroni criterion. Because the number of larcenies was falling throughout New York in the years of our

Figure 2
Grand Larceny Counts in Peter Cooper Village, Stuyvesant Town, and the 13th Precinct



Notes: PCV = Peter Cooper Village; ST = Stuyvesant Town.

study, it is reasonable to wonder whether the drop in larcenies seen in the 13th precinct simply reflects the overall drop in the city. As can be seen in Table 3, the mean number of larcenies in New York in the years 2002–2004 was 126,172; in the following 2 years, 118,140.5. This corresponds to a drop of 6.4%. This is marginally smaller than the drop of 6.0% in the 13th precinct. Consequently, the significant effect here probably represents effects of the larger crime drop that are not being captured by the linear time term in our regressions. On the other hand, the drop in the city as a whole is much smaller than the drop in larcenies observed in PCV (70.8%) or in ST (22.3%). Consequently, we conclude that the introduction of electronic monitoring may well have reduced the number of larcenies in

Table 3
Reported Larcenies in New York City, 2002–2006

Year	Larcenies
2002	129,655
2003	124,846
2004	124,016
2005	120,918
2006	115,363

Source: Adapted from Division of Criminal Justice Services (2007).

PCV and in neighboring ST. However, the failure of the coefficient to achieve statistical significance in the estimation for PCV means that we cannot speak with high confidence about a reduction there—in the location where we would expect the largest effect.

We concluded our analysis with 1 further set of tests. If the introduction of electronic monitoring produced any diffusion of benefits from PCV to the surrounding area, we would expect the associated drop in crime to be smaller in the adjacent regions as in PCV. CCTV cameras should operate most effectively as a deterrent where they are present. To assess whether this was the case, we conducted a Wald test for the equality of the coefficients for CCTV for larceny,[6] the 1 offense for which the magnitudes of the coefficients are in the predicted order. However, the differences were not statistically significant at the .05 level. When the estimates for PCV were compared just with those for ST, the coefficients were again not statistically significant from 0. Because it is implausible that electronic monitoring reduced larcenies as much in the surrounding areas as it did in PCV, we think it implausible that monitoring brought appreciable benefits to the nearby areas.

Conclusion

By estimating Poisson and negative binomial regressions for a number of different offenses, we found no persuasive evidence that the introduction of CCTV and ancillary electronic monitoring equipment to PCV in Manhattan reduced the incidence of crime in PCV. Because of the limited statistical power of our tests due to the modest number of observations (60) and the reduction in the degrees of freedom through the introduction of a time trend and dummy variables for months, we cannot exclude the possibility that monitoring brought about a modest reduction in the already low crime rate for some offenses.

In the adjacent apartment complex, ST, there was stronger evidence for the reduction of crime. Because of the higher level of crime counts in ST, reflecting its larger population, the statistical power of the analysis was larger, making it easier for the estimated coefficients to achieve significance. In the surrounding 13th precinct, the analysis pointed only to a significant reduction in larcenies. Because this reduction was comparable in magnitude to the decline in larcenies taking place throughout the entire city, there is no strong reason for considering it to be an ancillary benefit from the introduction of CCTV to PCV.

Though not definitive, our results suggest that CCTV may be moderately effective in preventing minor crimes or in diverting them to distant areas. Its effects on more serious crime could not be gauged precisely from this research because there was so little of it prior to the introduction of electronic monitoring. It would be easier to study the efficacy of monitoring on serious crime where there was more of it.

In a world of finite resources, implementation must also take costs into account, as well as effectiveness. Some of these costs are monetary, others are psychological and attitudinal. While some residents of an area may welcome the promise of increased security, others may resent the loss of privacy (Gallagher 2004). Some may become complacent; thinking that CCTV will protect them, they may become careless and fail to attend to possible risks. Others may be alarmed by the visual reminder that crime is enough of a risk to warrant protective measures (Ditton et al. 1999). In the study carried out by Musheno, Levine, and Palumbo (1978), the equipment seemed to do little to alleviate anxiety about crime. The surveillance equipment costs money—not just for the initial acquisition, but also for its replacement if vandalized. In the housing project studied by Musheno, Levine, and Palumbo (1978), the equipment was vandalized repeatedly.

If CCTV is to be effective, it must be monitored. This, too, can be expensive.[7] In an unregulated market, owners may be able to recoup the costs of buying and maintaining electronic monitoring systems. Tenants who think that the additional protection is not worth the extra rent will move out and be replaced by tenants who do. If too few tenants want to pay for the increase, owners will not install the equipment. Where rent control prevents owners from raising rents, CCTV could conceivably reduce the profitability of a rental investment.

Because our results suggest some potential benefit of CCTV in the form of crime reduction, we think further research on its impact is to be warranted. Because the benefits of reducing major crime are greater than of reducing lesser crimes, we suggest that future research focus on areas in which serious crime rates are higher than in PCV/ST. That research should focus on the manner of implementation, because the effects of monitoring may depend critically on how it is carried out.

Notes

1. See "Video Surveillance" (December 18, 2007) at www.privacyinternational.org (accessed April 22, 2008). Actually, the UK figure is only a rough estimate. Some authors suggest that the British figure is quite a bit smaller (Webster 2004).

2. Another measure of the level of crime is the proprietary index developed by the CAP Index Corporation, which compares measures of crime and loss vulnerability in specific locations with national state or county averages over time. In the CAP Index on May 24, 2002, PCV and ST score 13 and 65, respectively, while the national CAP index score was 474.

3. We tested this assumption by estimating models in which the effect of CCTV kicked in only after a lag of 1 or more months, but those models provided worse fits than the ones we present in the tables.

4. The Poisson regressions were estimated using Stata 10's poisson and glm routines.

5. Researchers who rely on Hilbe's (2007, 47-48) syntax for carrying out these tests should be aware that there are several typographical errors. In his syntax for the score test, on the bottom of page 47, the first 2 lines should be replaced by the single line, "predict mu." On page 48, in the numerator of equation 3.24, *y* should be replaced by y bar, and in the "display" line of the syntax for the Lagrange Multiplier test on the same page, *n* should be replaced by _*n*. Hilbe informs us that the second edition will incorporate these corrections.

6. The Stata manuals do not document this test. The syntax that performs it is

```
poisson larceny_pcv time month2-month12 cctv, score(s1)
est store pcv
poisson larceny_st time month2-month12 cctv, score(s2)
est store st
poisson larceny_13 time month2-month12 cctv, score(s3)
est store precinct
suest pcv st precinct
test [#1]cctv = [#2]cctv = [#3]cctv
```

7. Because watching video monitors in which nothing of interest is happening most of the time is inherently boring, there may be a problem in getting those watching the monitors to pay attention. In a case currently being investigated, a woman was raped for half an hour in the stairwell of a public housing project that was ostensibly being monitored by security cameras watched by New York Police Department officers, who evidently did not notice that a crime was taking place (Gendar 2008).

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