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Unveiling the Efficacy: Examining the Influence of Public Surveillance Cameras on Crime Rates

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Abstract

The importance of surveillance cameras in policing and security is hard to overstate. It can potentially enhance the operational capacity of law enforcement agencies by deterring crime and supporting investigation and prosecution. Now, it is possible to employ new, cost-effective technologies that can aid police in controlling the crime rate. Surveillance cameras have become an integral part of policing and security in Lahore. This study provides the first evaluation in Pakistan that examines the effect of surveillance cameras on crime. We have used '15' emergency helpline data and interrupted time series analysis to explore the impact of surveillance cameras on crime in Lahore. We found a statistically significant reduction in street crime in the short run, but no reduction was found in the long run. This could result from ineffective technology implementation or cameras installed only on a few major roads within Lahore. Further cost-benefit analysis of such technologies is required to take spillovers and the number of arrests into account to obtain more precise estimates.

Keywords: Economics of crime, Public surveillance cameras, Technology and policing, Deterrence, Interrupted time series analysis, Segmented regression

1 Introduction

No one must feel victimized or deprived of his hard-earned assets. To achieve sustainable development goals (SDGs), particularly goals 11 and 16, it is essential to maintain peace and the rule of law in cities and communities, implement property rights, and provide security and safety for the citizens that, as a result, make cities more sustainable. Effective policing is essential to maintaining peace in a society. It provides favorable conditions for businesses and other economic

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activities. Providing security and a peaceful environment where life is protected and predictable is important. The role of policing is very important in providing a societal environment and umbrella for economic development by protecting property rights. If law enforcement agencies (LEAs) cannot provide such an environment, it stalls economic growth (Khan et al., 2022).

Policing is difficult, especially with expanding urban boundaries and enormous population growth. By 2050, 6.5 billion of the population is expected to be urbanized, and it will expand by 95% in the developing world (World Urbanization Prospects 2018). Pakistan has the fastest pace of urbanization in South Asia, with a 3% annual growth rate. Currently, 40% of the population lives in cities; by 2025, it will become 50%. Furthermore, by 2030, 12 cities in Pakistan will cross the 10 million figure and get the title of megacities (Baqa et al., 2021). In this scenario, a weak policing system may increase criminal activities. Thus, it is necessary to adopt modern technologies to stop criminal activities and to drive sustainable development in populated cities. Only well-equipped and professionally competent police can meet these new challenges. Technology can help to make police more problem-oriented and proactive to reduce crime. Moreover, technology also assists in policing the police, for instance, monitoring and accountability of police officers. It makes police procedures more transparent, reduces discretionary powers, and enhances accountability (Indarti, 2020).

Rapid social change and expanding cities are potential breeding grounds for crime in cities (Dana et al., 2022; Kashef et al., 2021). There is a strong positive correlation between crime and urbanization, which poses a challenge for the police to reduce crime in populated cities to promote economic development (Silva & Li, 2020). The same challenge persists in Pakistan. Not only is the crime rate high in urban areas, but it is also growing faster than in rural areas (Cheema 2017). The mega-cities are facing an increase in criminal activities because of several socioeconomic factors such as poverty, unemployment, drug abuse, etc., along with inflation and low education (Gumus, 2004; Jabeen 2015). In urban territories, police face challenges such as improper information, identification, and anonymity (Cheema 2018). These are the main causes of the high crime rate in urban areas. Because unlike villages or small communities, in urban areas, people have limited information about criminal people. Moreover, the police force is not able to identify the criminal people. Consequently, the percentage of untraced criminal activists on record is twofold in crowded areas of Punjab (Ghosh, 2023). If a criminal activist is not nominated in the first investigation report (FIR), he is less likely to be penalized. Therefore, “urban anonymity” reduces the quality of the investigation. In turn, it debilitates the deterrence, as the chance of being caught is decreased. The surveillance cameras mitigate this anonymity problem and help investigate criminal activities.

The ratio of police manpower to population is also important in controlling crime (Vose et al., 2020). The ratio of police officers to the population in Lahore is alarmingly high compared to other metropolitan cities worldwide. The ratio is 1:413, compared to 1:98 in Delhi and 1:157 in London. In Lahore, only 1 police officer is recruited for 337 people, and a big chunk of it is deployed for its own and VVIPs security. Additionally, the per capita police expenditure of the Punjab Police is very low (Malik & Qureshi, 2021). Low per capita police expenditure also affects the performance of police. Hence, the deployment of surveillance cameras is enormously more cost-effective than the deployment of additional police officers. Therefore, surveillance cameras can potentially enhance the operational capacity of the police. The surveillance officers behind cameras are like invisible police and thus mitigate the risk of being victimized. As in Pakistan, the police are being targeted by terrorists as the symbol of the state. More than 1400 police officers had laid their lives in terrorist attacks.

Pakistan has faced a surge in terrorism from 2013 to recent years, and it has become a highly destructive phenomenon. Various steps are taken to control this menace at the federal and provincial levels. The provincial government of Punjab initiated a “Safe City Project” in 2016,

under which more than 8500 cameras are deployed in Lahore. The main purpose of this project is to counter-terrorism activities, reduce crime, and equip law enforcement agencies with modern technology. This study aims to investigate the effect of surveillance cameras on crime. Very few studies on this topic have been done in the literature on economics. The studies mentioned in the literature review show limited and institutional diffusion of cameras. This research study contributes and stands out in this literature as it evaluates the blanket coverage diffusion of surveillance cameras. Moreover, it is the first time this kind of study has been done in Pakistan, to our knowledge. In addition, it will also contribute to the literature of criminology.

1.1 Surveillance Cameras in Policing

In the developed world, cameras are now integral to the policing and criminal justice system. They tend to mitigate the urban anonymity challenges and enhance deterrence. Photography was first used in 1850 for criminals' and prisoners' identification and documentation purposes. The first live monitoring of a public event by police was recorded in 1947 when the Metropolitan Police utilized the BBC live broadcast to monitor a Royal marriage ceremony and for assistance in deploying the police force. At the beginning of the 1950s, cameras began to assist in traffic monitoring and management. By 1960, police had cameras to monitor different state and public events. The retail sector deployed CCTV in the same decade to deter and catch shoplifting. CCTVs were commercialized then, and companies started marketing CCTV systems for security purposes (Bernot & Smith, 2023).

Privacy is a major concern in the deployment of surveillance cameras. To what extent can government institutions get into people's lives for security? Surveillance officers in centralized control rooms have more discretion to breach people's privacy than police officers in the field. Therefore, sign boards are displayed at public locations where people are monitored. Technologies like surveillance cameras should be checked and discussed by citizens. Who can access and see the feed of public surveillance cameras? Rigorous standard operations procedures should be adopted to prevent any privacy breaches. PSCA has a data protection and privacy policy (Khan, 2018). The large number of private cameras placed in public places employed by firms and individuals capture extensive data. There is no law to prohibit data capturing and storage in public spaces. The government should regulate it.

1.2 Diffusion of Cameras

Nix et al. (2020) have discussed four levels of diffusion of cameras.

1. Private diffusion: The private sector, particularly banks and supermarkets, embraced this technology to deter robbery, theft, and fraud. The scale is relatively small, but quality and use vary accordingly.
2. Institutional diffusion: Public places like transportation and educational institutes vulnerable to crime and other threats use cameras.
3. Limited diffusion: where cameras are used in public spaces in towns and cities to enhance the capacity of security forces to deter crime. At this level, local governments deploy surveillance systems. Normally, limited resources are utilized at this level. For instance, small, centralized control rooms with dedicated staff are designed for monitoring and communication with police.
4. Blanket coverage: Many centrally located cameras covers the whole city. These systems are integrated with other law enforcement agencies and emergency services.

Historically, technological interventions – both hard (such as CCTV, biometrics) and soft (information based; crime mapping and analysis, profiling) technology, have evolved dramatically

and transformed law enforcement organizations – policing style and practices (Byrne, 2011). Information technology has made it possible to send and receive an enormous amount of data from one point to another, store data centrally, and access it from anywhere. Therefore, it is now possible to centrally monitor the live streaming of thousands of cameras within a single roof. This invisible policing enhances police efficiency, as it is more cost-effective than deploying many police officers in the field. Besides, this reduces risk in many cases as well.

In the past couple of decades, there has been rapid growth in the deployment of surveillance cameras (Piza et al., 2019). The US, the UK, and China have largely expanded surveillance capacity through cameras. The other reason that helps to prevail this technology in security and policing is that it has become cheaper over time. In the United States, more than 15000 surveillance cameras have been installed in Chicago (Stoughton, 2022). China has installed 170 million surveillance cameras nationwide (Aho & Duffield, 2020).

1.3 Surveillance Cameras & Crime

In a meta-analysis study, Khan et al. (2020) found that surveillance cameras reduced the crime rate significantly, and the impact is high in parking lots and public transit systems. However, they have a low impact in public housing communities. Results of camera-based surveillance systems vary across crime categories. However, most reduction in crime was found in violent crime and theft (Hernández, 2019; Shepley et al., 2019). There is a dearth of literature on the impact of surveillance cameras on crime in economic literature. However, criminology literature suggests that surveillance cameras significantly reduce crime (Gómez et al., 2021).

Alexandria (2017) used differences in different strategies. She found that surveillance cameras reduced overall crime by 20% in Stockholm's 84 Subway Stations, and a 20-40% reduction was seen in planned crimes such as theft, robbery, and drug peddling. However, no effect is observed on crimes such as assaults. This study has also estimated the placebo treatment effect during the announcement and installation period of surveillance cameras, and no evidence has been found of the change in crime rate. (Gómez et al., 2021) found that surveillance cameras reduce crime rate by 23% in Medellin, Columbia. Secondly, the arrest rate declined by 31%. This research study also measured the spillover; however, no such effect was observed. Aba et al. (2016) studied the impact of cameras on theft and mutilation in the University of Agriculture, Makrudi library. They found a 34% decrease in theft and mutilation.

Public surveillance cameras have a smaller deterrence effect on terrorism activities. Stutzer and Zehnder (2013), found limited evidence of cameras' effectiveness. This may be because of the limited ability of the police to react timely during criminal activity. Another important aspect to measure the deterrence effect of surveillance cameras is the spillover effect. If there is a reduction in crime at locations where cameras are installed and a crime surge where cameras are not present, then we can interpret our results as causal. It becomes easier to measure crime displacement by employing new technologies such as Geographical Information System (GIS) and spatial analysis (Wickremasinghe & Kaluthanthri, 2021). The GIS helps identify crime pockets in cities and assists police in decision-making. So, resources are more efficiently deployed in places that are more vulnerable to criminal activities.

2 Theoretical Background

Becker (1968) and Enrich (1973) introduced an economic approach to crime. Their theoretical model posited that criminals are also economic agents who behave rationally. Their model predicts that the chance of committing a crime is low if the marginal cost of crime is higher than the marginal benefit. The following are the parameters of Becker's (1968) model, as Doleac (2017) explained.

I. The first parameter is the probability of conviction. The cost of committing a crime can

be increased by enhancing the probability of being caught and convicted. This is called the "deterrence effect." If the chance of being caught is high, it can deter the offender from committing a crime. In previous criminology literature, it is estimated that increasing the number of police officers had a negative impact on crime as it created the deterrence effect.

II. The second parameter is imprisonment, where the imprisoned offender is unable to commit a crime or re-offend again. This is the "incapacitation effect." Incapacitating criminals may require prisons and their management and, therefore, may not be cost-effective. However, it is expensive to implement a policy based on the incapacitation effect. Empirical evidence shows that incapacitation and deterrence have a negative impact on crime (Doleac 2017).

III. The third aspect is punishment; the strict and harsh punishments influence the offender's behavior if he discounts the future. Increasing the expected sentences deters criminal behavior (Kilmer & Midgette, 2020). However, the deterrence effect may vary among age groups, especially in longer sentence prospects (Stam et al., 2023). Furthermore, there is evidence that harsh and long punishments can affect criminal behavior negatively (Pritikin, 2008).

In light of the above-mentioned model, it is proposed that camera installation could enhance the probability of getting caught and convicted. In economic terms, this means that the marginal cost of committing a crime has increased. Figure 1 depicts such a change in the marginal cost of crime for the potential offender. This may result in changing the behavior of an offender, as shown in the figure below. This leads us to our hypothesis that with the installation of cameras, crime rates in Lahore will decrease.

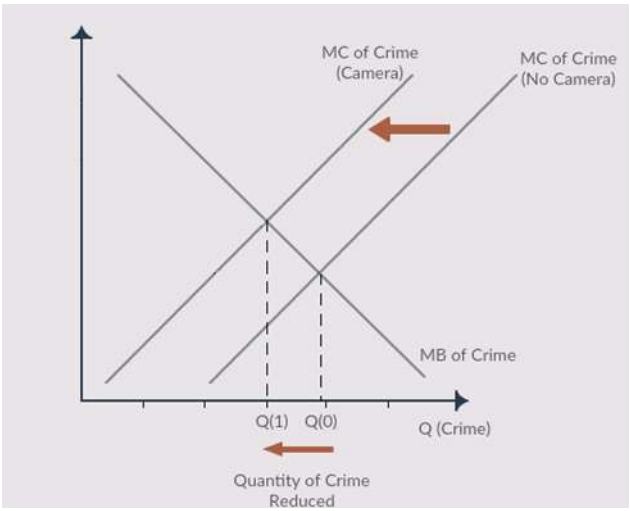

Figure 1: The effect of surveillance cameras on crime rates

The above model has similarities with the effect of the "panopticon." It is the idea given by British philosopher Jeremy Bentham in 1843. For example, prisoners are occupied in a circular building and can be watched through a tower at the center. All the cells are visible, but the watchmen in the tower are not visible to the prisoners. This intruded into prisoners' minds, causing them to be watched constantly, and if they violate any rule, they can be punished. That subtly compelled them to regulate their behavior.

This parable seems very effective and compelling for criminology and sociology literature. The deployment of surveillance cameras is the modern illustration of the "Panopticon" for the criminals that deter crime. Surveillance cameras are like a central tower, operated by unseen surveillance officers. It is irrelevant whether the camera is working or not; the mere presence of a camera is enough to influence the behavior of offenders. The deployment of surveillance cameras is an "electronic panopticon" for the criminals (Parreno & Demeterio III, 2021).

3 Methodology

We use administrative data to study the effect of public surveillance cameras on crime. Data from 15 (Police emergency helpline) calls from October 2016 to December 2018 is used to study the effect of surveillance cameras on crime rate. Data of 15 consists of thousands of calls relevant to criminal offenses reported at the Emergency Command Center (ECC) of Punjab Safe Cities Authority (PSCA) in Lahore, Pakistan. The data is generated through Computer Aided Dispatch (CAD) with responses, and the data is disaggregated by division, police station, and crime categories. We do not have the data before that period because CAD was implemented in October 2016.

The data is extracted from the CAD database and is pertinent to crime. We are interested in criminal offenses typically committed on streets or publicly, usually known as street or property crimes. It may have been mostly affected by the installation of surveillance cameras. In this regard, we generated the dataset that includes counts of calls related to Theft, Robbery, Dacoity, Vehicle Snatching, Vehicle Theft, and Burglary. This study considered only those calls received at ECC, on which a police team was dispatched to the locations where force was required. Lahore is divided into six police divisions, and police stations differ in characteristics, mainly in area size, population density, and number of police stations.

Data is sorted weekly for analysis. We use information from the newspapers to obtain the exact dates the camera installations started and completed. The project was initiated in October 2016. The installation of cameras in the City and Civil Lines divisions was completed in March 2017, and in the rest of the divisions, such as Iqbal Town, Model Town, Saddar, and Cantt, it was completed in June 2017 Ash.

4 Descriptive Analysis

Lahore's crime level is moderate (Memon et al., 2022). The following Figure 2 presents the summary statistics for weekly crime trends in Lahore by division and category, including data from October 2016 to December 2018.

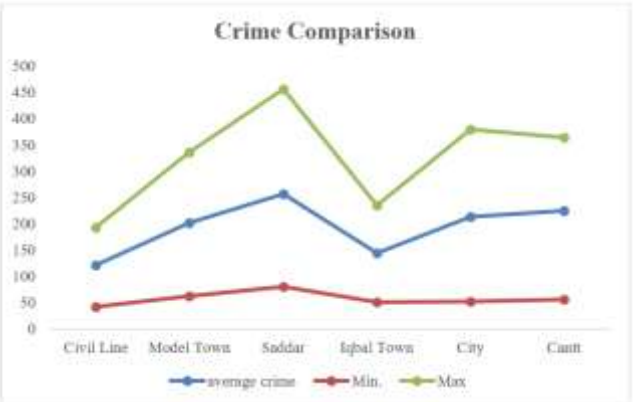

Figure 2: Summary Statistics of Crime in Lahore

The average weekly number of overall crimes reported in Lahore is 1163, with a median of 1089. The minimum number of crimes reported per week is 357, and the maximum is 1947. The Saddar Division ranked 1st in the crime rate, as on average, 256 cases were reported per week, and the median number is 236. It also has the highest weekly theft, robbery, and burglary cases—the Cantt. Division followed Saddar Division with an average of 225 and a median of 213 cases per week. The City Division is in third place with average cases of 213 and a median of 201. This division has the highest cases of vehicle theft and has the second highest cases of robbery after the Sadar division. After the City Division, the highest numbers of cases of crime were reported in the Model Town Division, where on average, 201 were registered with a median number of 188. The Iqbal Town Division is in fifth place in crime rate, with an average of 144 cases per week and a median of 140. The Civil Lines has the lowest crime rate as 122 cases were reported on average, and the median number is 117.

The Saddar and Cantt Divisions are the largest in area size. They are twice the area of the City and Civil Line divisions. The population density varies in different locations of both divisions. Moreover, the City and Civil Line are highly densely populated divisions. The infrastructure of the City division is poor and congested at large compared to other divisions. The Civil Line and Model Town divisions have well-planned infrastructure, and overall per capita income is higher than other divisions.

Figure 3 illustrates the summary statistics graphically. It shows that a big chunk of crime is pertinent to two categories: theft and Robbery. Very few matters of more organized crimes, such as Vehicle snatching and Dacoity, are reported. The burglary rate is moderate compared to other Theft and Robbery.

Figure 3: Crime incidents in Lahore, by category

Figure 4 illustrates the frequency of different crime categories in Lahore over the given period of time. The ratio between different crime categories is nearly the same in all divisions.

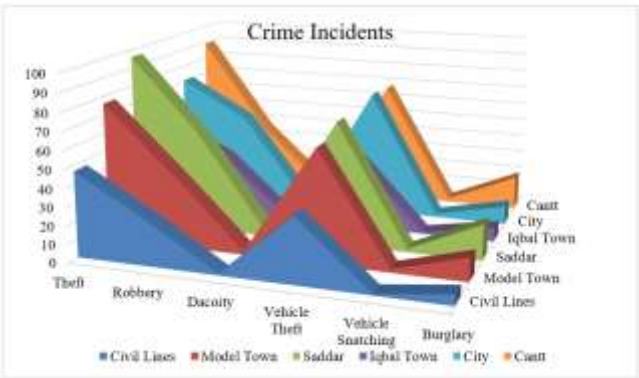

Figure 4: Crime incidents in Lahore, by division and category

Figure 5 displays the crime trend from October 2016 to December 2019 in Lahore and its divisions. The vertical dotted line is the time when the camera installation was completed. The red line is the ITS regression model, and the dotted red line is counterfactual. The light red dots represent the trend of crime at weekly intervals.

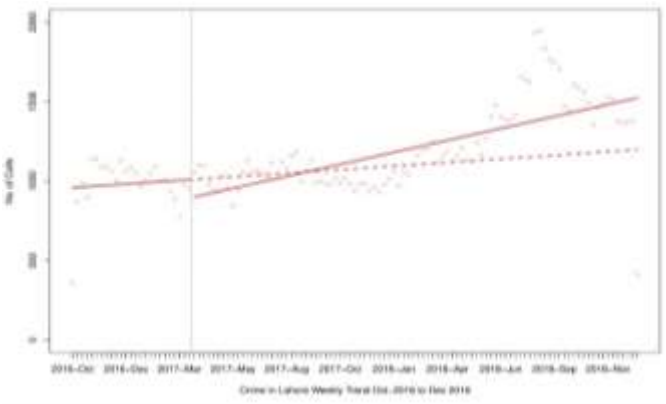

Figure 5: Weekly crime trend before and after installation of cameras in Lahore

4.1 Empirical Strategy

Subsequently, we used Interrupted Time Series Analysis (ITSA) to measure the impact of the camera installation in Lahore, estimating the level and trend in crime rate after installing public surveillance cameras. ITSA is a quasi-experimental design that enables researchers to estimate causal effects. It is used to evaluate the longitudinal effects of interventions using a regression model. It is useful when randomization is not an option and control design is not feasible or affordable. In this study, the simplest form of the ITS modeling approach is used. In this form, ITS is modeled using a segmented regression model. It includes three time-based covariates. The analysis is conducted in two parts: for overall crime reduction after the camera's intervention. In the second part, we saw the treatment effect on each crime category. For ITS analysis, the following segmented regression model is used:

$$\mathbf{Vit = \beta 0 + \beta 1 Time + \beta 2 Camerait + \beta 3 Time * Camerait + \mu i + \varepsilon it}$$

Vit is the log of the crime rate at time t, where the time intervals are measured in weeks. The camera is the dummy variable indicating the pre-installation period as 0 or 1 for the post-installation period. Time is the time that elapses from the start of the study in several weeks. β0

represents the baseline level at Time = 0, β1 controls for natural time trend associated with crime in Lahore, β2 represents the change in crime due to the installation of cameras, and β3 indicates the long-term effect of camera surveillance. μi is the fixed effect that controls for unobservable heterogeneity within the divisions. In other words, it controls for unobserved characteristics of each division. To check the robustness, we run the model without a division fixed effect to see the variation in the results, and the results are not far from the division fixed effect. The data is sorted at weekly intervals as we have very limited data for only 28 months. Therefore, by doing it every week, the data set remains huge enough. Consequently, we have more statistical power. We have used RStudio, ggplot library for plotting graphs, stargazer library for generating descriptive and regression tables, and other libraries for different analysis steps.

5 Results & Discussion

Table – 1, reports the main results. There is a significant effect of public surveillance cameras on crime. Column 1 shows the result of an overall reduction in crime in Lahore. The estimated effect is 21.3% and is statistically significant at p<1%. Column 2 shows the overall crime rate using division fixed effects. The estimated effect is 16.5% in divisions of Lahore after the installation of cameras, and the result is significant as p<1%. Column 3 shows that there is a 55.3% reduction in theft cases. Column 4 shows a 49.5% reduction in theft using the division fixed effect. The effect on theft, with or without division, is statistically significant.

Results in column 5 show an 8.1% decrease in robbery without a division fixed effect. Column 6 shows the effect on robbery with the division fixed effect, and the reduction is only 4%. However, results for robbery are not statistically significant. Column 7 shows approximately a 4.3% increase in Dacoity cases without division fixed effect. Column 8 shows almost a 7.3% increase in Dacoity incidents, with division fixed effect. The results for Dacoity are not statistically significant. Column 9 shows a 24.3% increase in vehicle thefts after the installation of cameras without using the division fixed effect. Using the division fixed effect, column 10 shows approximately a 26.3% increase. The results for Vehicle Theft are statistically significant at the 1% level. Column 11 shows a 44.2% increase in Burglary without a division fixed effect. Column 12 shows around a 58.5% increase in Burglary, using the division fixed effect. The results for Burglary are highly statistically significant at a 1% level.

Following is an estimation of the economic burden of theft and robbery in monetary terms based on the assumed average cost of both. The average weekly theft count is 423, and after the above-mentioned 49.5% reduction in theft, there are 207 fewer incidents of theft. If the average theft cost is one thousand rupees, then the economic burden of 0.82 million is reduced monthly. Furthermore, the average weekly robbery count is 242, and after the above-mentioned 4% reduction in robbery means, there are 10 (approximately) fewer robbery incidents. And if the average cost of robbery is ten thousand (10,000) rupees, it reduces the monthly economic burden of 0.50 million rupees. In theft and robbery cases, this intervention reduces the economic burden by more than PKR 15.5/- million annually. This is a chunk of the economic burden that surveillance cameras are reducing as it did not include the other benefits such as the cost of other crime categories, assistance in the investigation and criminal justice system, etc.

The coefficients are quite similar with and without adding the division fixed effect, which shows the robustness of the estimates. The camera and week interaction variables are mostly zero for overall crime and all categories, even after we added the division fixed effect. So, this represents that in the long term, the camera effect is not much on crime. It is slightly upward in the case of vehicle snatching. All the results are highly statistically significant except for Robbery and Dacoity.

We also found a reduction in robbery and snatching incidents. Vehicle snatching is a rare crime; therefore, we have seen a great reduction in it. However, it had an effect on planned crimes—as more trained gangs are involved, such as Dacoity and Vehicle Theft. We also found that there was a surge in burglaries after the intervention of surveillance cameras. By definition, burglary is a theft that happens within the perimeter of a private building. Therefore, it has less effect on cameras.

Table 1: Effect of Public Surveillance Cameras on Crime in Lahore

	Total			**Theft**			**Robbery**			**Dacoity**			**Vehicle theft**			**Burglary**		
	Overall effect	division effect	fixed	Overall effect	division effect	fixed	Overall effect	division effect	fixed	Overall effect	division effect	fixed	Overall effect	division effect	fixed	Overall effect	division effect	fixed
	(1)	(2)		(3)	(4)		(5)	(6)		(7)	(8)		(9)	(10)		(11)	(12)	
Constant	4.976***	5.175***		4.319***	4.555***		3.291***	3.290***		0.582***	0.753***		3.529***	3.718***		0.817***	1.350***	
Week	0.006***	0.004***		-0.002	-0.005***		0.010***	0.008***		0.002	-0.002		0.015***	0.014***		0.041***	0.035***	
Camera (Yes)	-0.213***	-0.165***		-0.553***	-0.495***		-0.081	-0.040		0.043	0.073		0.243***	0.263***		0.442***	0.585***	
Camera*Week	0.001	0.002*		0.008***	0.010***		-0.003	-0.002		-0.004	-0.001		-0.010***	-0.010***		-0.023***	-0.019***	
Observations	702	702		702	702		702	702		438	438		702	702		693	693	
Region Fixed Effect	No	Yes		No	Yes		No	Yes		No	Yes		No	Yes		No	Yes	
R2	0.180	0.675		0.106	0.593		0.189	0.563		0.025	0.138		0.227	0.551		0.505	0.736	
Adjusted R2	0.176	0.671		0.102	0.588		0.186	0.558		0.019	0.122		0.223	0.546		0.503	0.733	

*Note: *p**p***p<0.01*

Furthermore, the generalized least square function is used in R to create trends before and after the installation of the camera. It also represents the counterfactual on the post-intervention side, which is represented by a dotted line following the pre-intervention trend. We don't find any long-run effect; it might be because of a surge in crime between election time spans when the caretaker government shuffled the police officers at all tiers. Or is there anything else that occurred that influenced the results and the crime rate? It might be because of the spillover effect that crime shifts from places where cameras are far away, such as in residential areas. The surge in burglary during this time period also supports this argument. However, our assumption for the analysis is that there is blanket coverage diffusion of surveillance cameras in the city.

As our data contains the count of calls received at the emergency helpline, the police adopted a new response system with the intervention of CAD implemented by PSCA, as mentioned earlier. The PSCA has run a huge electronic, print, and social media campaign through its Media Monitoring Cell (MMC) for public awareness that is "Dial '15' in case of emergency". Moreover, during this time, people's trust has been built due to this new response management system. Consequently, this increases the number of calls on the emergency helpline, and as the trend of approaching police helpline rises, it also affects our estimates. There is an argument found in the literature that the reduction in cameras may be not only because of cameras. Other policies also influence the crime rate during the study period. The installation of cameras in Lahore is exogenous; all other policies were constant during the study period. The Dolphin force that is being used as a patrolling force is the first respondent to the crime scene and collaborates with the integrated command center. The Dolphin Force project was implemented and completed in 2015 (Ghumman, 2015). Thus, the impact of dolphin force in our study is endogenous. However, the intervention of an integrated command center through which a new 4G communication system was introduced that replaced the previous wireless system. This new response mechanism, which reduces response time, may also affect the crime rate. For example, interrupted time series analysis assumes that there is only one change, i.e., cameras, and no other changes during the study period to give a causal estimate.

Conclusion

The main objective of this study was to estimate the impact of the public surveillance cameras on crime. We use the theoretical background of Becker (1968) and Enrich (1973) to arrive at our hypothesis that cameras reduce crime rates. Furthermore, we also relate the concept of "Panopticon" by Bentham (1843). Then, we utilize the data from '15' calls. The count of calls is close to real crime incidents, as compared to complaints registered at police stations. The surveillance cameras in Lahore reduce the overall crime rate. However, we don't find any long-run effect on crime. We anticipated that, in the short run, the surveillance cameras would deter crime, but over time, crime would relocate to other areas of Lahore. We have seen a reduction in theft and robbery but an increase in burglary (see definition of burglary and theft in appendices). That can be interpreted as shifting crime from main roads to housing areas. We don't see any change in planned crimes such as vehicle theft and Dacoity in which gangs and trained individuals are involved. However, the importance of surveillance cameras in policing and security cannot be ruled out.

It is obvious that crime imposes a cost on society, but then it is very difficult to estimate the economic burden of crime on society. There is no need to study that cost to verify it. Complex and enduring integration requires investigation of the social harms, which is also difficult to measure (Chalfin 2015). However, we tried to estimate the monetary burden roughly. First, by assuming the cost of each theft and robbery, we calculated that assumed cost with our data and results. It was estimated that the surveillance cameras reduce the economic burden of theft and robbery by 0.82 and 0.5 every month. The only decrease in these two criminal activities is reducing the economic burden by more than fifteen and a half (15.5) million rupees annually. This does not include other benefits such as the cost of other crime categories, assistance in investigation, the criminal justice system, etc.

This study will also be a contribution to the literature of criminology. Very little knowledge is available on this topic that gives rigorous results. We had very limited data for analysis. Especially we did not have as much data on crime for the pre-intervention period. We did not completely control the phase-in installation of cameras at the division level due to the availability of information. If we had data on coordinates, spatial analysis could have been done to measure the causal impact. The results of this study could have external validity as criminals behave and act similarly in the presence of surveillance cameras. However, there is room for more research that estimates the spillover effect and increase in the number of arrests. Furthermore, taking account of exogenous variations and solitary policy intervention would help decide whether cameras should be adopted or not.

The prevalence of surveillance cameras triggered the debate on public space, privacy, and security. A major concern about privacy pops up with it. The potential financial and societal costs require greater research. Strict private policies must be implemented to comply with proper Standard Operating Procedures (SOPs) who have access to that data. The use of surveillance cameras must be indicated by clear signs in public places.

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7 Appendices

7.1 Definition of Crime Categories:

The following is a description of how an offense is classified into different categories to distinguish the categories mentioned in our data and results.

Table 2: Definitions of Crime Categories

Rubric	Definition
Theft vs. Burglary	Most of the time, theft, burglary, or stealing are considered the same

	term, but there is a slight difference between them. Burglary is theft that occurs within the parameters of private property. Burglary is an offense in which someone enters someone's property to commit some crime
Robbery	When any kind of force, weapon, harm, or fear is involved in an act of Theft, it turns into Robbery[5]. Snatching is also considered as Robbery in our dataset. Even if there is no weapon involved.
Robbery vs. Dacoity	The only difference between both is the number of participants. In Dacoity, number of offenders is five or above, it is regarded as a more serious offense than Robbery[6]

4 Pakistan Penal Code, Section 378. Defines Theft: "Whoever, intending to take dishonestly any movable property out of the possession of any person without that person's consent, moves that property to such taking, is said to commit theft."

5 PPC Section 390 defines "Robbery". "Robbery. —in all robberies, there is either theft or extortion. Theft is Robbery if, to commit the theft, or in committing the theft, or in carrying

away or attempting to carry away property obtained by the theft, the offender, for that end, voluntarily causes or attempts to cause to any person death or hurt or wrongful restraint, or fear of instant death or instant hurt, or instant wrongful restraint."

6 Pakistan Penal Code, Section 391, defines Dacoity.

Sub Categories of crime:

Our data also divide crime into sub-categories. Table 7.2 shows how crime is divided into further categories.

Table 3: Crime categories and subcategories

Theft	**Robbery**	**Dacoity**	**Burglary**	**Vehicle Theft**
Mobile Cash	Road	Dacoity	Dwelling Burglary in the night	Motorcycle
Bicycle	Personal	Dacoity with Murder	Other Burglary	Car
Theft Caught	Other		Dwelling Burglary in the day	Other Vehicles
Shop Lifting	Snatching		Commercial Burglary	
Personal	House		House Burglary	
Other	Shop		Burglary in Process	
	Jewelers Shop		Shop Burglary	
	Robbery with Murder		Bank Burglary	