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Pollution *or* crime: The effect of driving restrictions on criminal activity☆

Paul E. Carrillo*, Andrea Lopez-Luzuriaga, Arun S. Malik

George Washington University, United States

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ABSTRACT

Driving restriction programs have been implemented in many cities around the world to alleviate pollution and congestion problems. Enforcement of such programs is costly and can potentially displace policing resources used for crime prevention and crime detection. Hence, driving restrictions may increase crime. To test this hypothesis, we exploit both temporal and spatial variation in the implementation of Quito, Ecuador's *Pico y Placa* program, and evaluate its effect on crime. Both difference-in-differences and spatial regression discontinuity estimates provide credible evidence that driving restrictions have increased crime rates.

1. Introduction

Many cities in Latin America, Asia and Europe have imposed restrictions on the use of motor vehicles in an effort to reduce traffic congestion or improve air quality. The restrictions limit use of vehicles in either all or part of a city for part of the day.[1] The various programs differ in terms of the types of vehicles that are targeted, the size of the restricted zone, and the times of day during which restrictions are in effect, but they share common goals of either reducing traffic congestion or improving air quality, or both.

A number of studies have examined the effectiveness of these programs, focusing primarily on their ability to improve air quality. Mexico City's program has received the most attention,[2] but recent papers also examine the programs in Sao Paolo, Bogota, Beijing,

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* Corresponding author.
E-mail addresses: pcarrill@gwu.edu (P.E. Carrillo), aflopez@gwu.edu (A. Lopez-Luzuriaga), amalik@gwu.edu (A. Malik).

[1] The best known is Mexico City's *Hoy No Circula (HNC)* program introduced in 1989 to improve air quality. Sao Paulo (Brazil) and Bogota (Colombia) introduced similar programs in 1996 and 1998, respectively. Beijing and Tianjin (China) introduced temporary driving restrictions during the 2008 Olympic Games. Athens (Greece) introduced permanent driving restrictions in 1982. Santiago (Chile) has used a combination of permanent and temporary driving restrictions since 1998 to reduce air pollution. Most recently, in 2015, Paris and several cities in Italy introduced temporary driving restrictions in response to poor air quality

[2] See, for example, Eskeland and Feyzioglu (1997), Davis (2008), and Gallego et al. (2013).

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Tianjin, Santiago and Quito.[3] Most studies in the literature conclude that permanent driving restrictions have not reduced traffic congestion or air pollution. Where reductions have been detected, they have been short-lived, lasting less than a year. The exceptions are the studies of Beijing and Quito's programs, where noticeable improvements in air quality are attributed to the implementation of driving restrictions. Viard and Fu (2015) find that every-other-day driving restrictions in Beijing decrease pollution levels by as much as 19%; Carrillo et al. (2016) show that Quito's driving restriction program, which restricts vehicles one day a week during peak hours, reduces carbon monoxide levels by almost 10%. The "success" of Quito's program is attributed, to a large extent, to its strict enforcement.

In this paper, we identify a side-effect of driving restrictions that has yet to be studied: driving restrictions may *increase* crime rates.[4] It is clear that driving restrictions can have a direct impact on congestion and pollution, but, why would they affect criminal activity? The crime-and-punishment literature suggests at least two reasons. First, enforcement of driving restrictions is a resource-intensive endeavor that is typically the responsibility of the police. The marginal cost of committing a crime depends on the frequency with which criminal activities are detected. When driving restrictions are imposed, the burden of enforcement could result in fewer policing resources being allocated to crime prevention. As crime prevention decreases, so does the marginal cost of committing a crime.[5] Second, the cost of committing a crime also depends on the availability of opportunities to engage in criminal activities. If a driving restriction policy is successfully enforced, it can increase pedestrian flows and public transportation use, raising the number of potential victims. In equilibrium, a decrease in the marginal cost of committing a crime would result in higher crime rates.

To test these hypotheses we evaluate the effects of Quito's *Pico y Placa* program on crime. *Pico y Placa* (PyP) went into effect in Quito on May 3, 2010. It restricts access to the central part of the city. The last digit of a vehicle's license plate number determines the one day of the week on which the vehicle is barred from the road. The PyP program is well suited to being studied because of the availability of data on criminal offenses for the parts of the city that are subject to PyP restrictions as well as those that are not. Moreover, the program restricts vehicles during workday rush (or peak) hours but not weekends or holidays. These features of the program are exploited to identify treatment effects.

Crime data were gathered from two sources. The first is the Ecuadorian National Police. We obtain records of every crime reported to the police between January 2010 and May 2012 in Quito and Guayaquil, the two largest urban areas of the country. Our second source of data is Quito's Municipal Government ("Observatorio Municipal Ciudadano OMS"). OMS collects crime data from the police and creates monthly reports on citizen security. They shared all of their property crime records for the period 2008–2012. Each of these two data sources has advantages and weaknesses. The police data is for all crimes reported to the police. This data has information on the time of each crime, but it does not have geocoded information on location of the crimes. The police data are used to calculate the number of crimes of all types that took place every *hour* in Quito and in Guayaquil. The OMS data from Quito's municipality is a subset of the police records with geocoded information on the location of crimes. Unfortunately, OMS data are not comparable across time. Their sample selection criteria changed in April 2009 and reverted back a year later.

Police crime data and a difference-in-differences (DD) strategy are used to assess whether crime rates during the hours when PyP is in effect changed after the introduction of the program. In all specifications, the treatment group is working-day peak hours in Quito. Finding an appropriate control group is not straightforward. Ideally, one would want a control group that, in the absence of treatment, has the same trend as the treatment group. Rather than making an *ad hoc* choice, we use three alternative control groups, each of which can be a reasonable representation of the counterfactual trend under appropriate conditions. The control groups are: a) non-working-day peak hours in Quito, b) working-day off-peak hours in Quito, and c) working-day peak hours in Guayaquil. Our regression models include a comprehensive set of controls, including month-year fixed effects, day-hour fixed effects obtained by interacting each hour of the day with each day, and a long list of weather variables. Results show that crime rates in Quito increased during peak hours after the introduction of PyP relative to changes in each of the control groups. The magnitude of the effects is large, between 5% and 10%, and statistically significant at conventional levels. Estimates from our preferred specification suggest that PyP led to an increase of about 0.4 crimes per hour (about 10%) during the restricted hours. Models are also estimated with several "placebo" samples and no statistically significant results are found.

OMS data are used to analyze changes in the spatial distribution of crime before and after PyP was introduced. We focus on the spatial distribution of crime near the boundary of the restricted zone. The portion of the boundary that passes through populated areas is demarcated by major roads. These roads had a strong police presence before the introduction of PyP. Policing resources on these roads, and adjacent areas, are likely to have been diverted to staff a small number of PyP checkpoints located on the boundary. Thus, intensity of PyP enforcement and the potential for displacement of policing resources is likely higher along the boundary. We show that the post-treatment frequency of crimes as a function of the distance to the boundary has a large spike, or "excess bunching," at the boundary. The estimate of excess bunching is large: about 1.6 crimes per meter, over 60% higher than the baseline predicted by a counterfactual without excess bunching. More importantly, we show that in the pre-treatment period, there is very little excess bunching at the boundary.[6]

Excess bunching is much higher in areas just inside the boundary compared to areas just outside. Though the displacement of policing resources may nor may not affect both sides of the boundary, driving restrictions can disproportionately affect economic activity and pedestrian flows inside the restricted zone. For these reason, we also employ a spatial regression discontinuity design to assess if crime rates change discontinuously at the boundary. Intuitively, crime rates just inside the boundary are compared to their counterparts just outside. While in a comparable pre-treatment period the spatial distribution of crime is smooth around the driving restriction boundary, there is a sharp spike just inside the restricted zone in the post-treatment sample. Our preferred model's estimates suggest that PyP has increased the number of crimes along the inside edge of the boundary by as much as 100% compared to crime rates on the outside edge.

The combined empirical findings provide credible evidence that PyP has increased crime rates in Quito during peak hours and near the driving restriction boundary. Do these increased crime rates

[3] Lin et al. (2011), Chen et al. (2013), de Grange and Troncoso (2011), Troncoso et al. (2012) and Bonilla (2016).

[4] Davis (2008) is the only study we are aware of that briefly mentions this possibility.

[5] DiTella and Schargrodsky (2004) and Draca et al. (2011) offer evidence that police presence reduces crime.

[6] The difference between post and pre-treatment excess bunching is 1.39 crimes per meter.