Crime and political effects of a concealed weapons ban in Brazil[*]

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Abstract

This paper studies the effects of legislation in Brazil that banned the carrying of concealed weapons nationwide in 2003, and provided for a voter referendum 22 months later regarding whether to ban the sale of all firearms in Brazil. Using a regression discontinuity design, I find that in the wake of the law gun-related homicides decreased by 10.8 percent, with the reduction especially pronounced among young black males living in high-crime areas. Other crimes involving guns (robberies) also declined, while crimes that did not involve guns were unaffected. Enrollment in adult education courses disproportionately increased in areas that saw the biggest drop in gun-related crimes. Economic benefits are estimated to exceed $3 billion. Analysis of the subsequent voter referendum, which was defeated by a wide margin, shows higher voter turnout and stronger support for the complete weapons ban in the areas that had experienced the greatest decline in gun-related homicides.

JEL: D72, H11, I12, J17, K14

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1. Introduction

How do laws that regulate the carrying of concealed weapons affect levels of violence in society? Is violence reduced by enacting laws that allow citizens to carry concealed weapons, or by laws that forbid the carrying of concealed guns? On one hand, allowing citizens to carry concealed weapons may deter criminals from committing a crime because they may think that their intended victims could be armed. On the other hand, laws that forbid the carrying of concealed weapons may decrease violence by reducing the odds of serious injury or death occurring during criminal encounters or in disagreements that escalate. Extensive research has been conducted to understand the impact of laws that allow citizens the right to carry concealed weapons, but it has proved to be a very difficult subject of study; empirical results are sensitive to minor variations in the data and model specifications, delivering mixed conclusions (Manski and Pepper 2016).[1] As a result, the broad impacts of such laws are not clear, and little is known about who, if anyone, benefits from such legislation, and how this relates to the prospects for and public views of gun legislation.

This paper approaches the question about how concealed weapons laws affect violence by measuring the impact of a nationwide law that banned (rather than authorized) the carrying of concealed weapons. I examine gun-carrying restrictions that were passed by the National Congress of Brazil, and implemented in December 2003 in Brazil. The legislation prohibited carrying concealed weapons, and provided for a subsequent referendum 22 months later to allow voters to decide whether to implement a more stringent law to completely ban the ownership of weapons and ammunition. The implementation of the law and the provision for the follow-up referendum

[1]See, for example: Lott and Mustard 1997; Ayres and Donohue 1999 and 2003; Black and Nagin 1998; Duggan 2001; Ludwig 1998; Aneja et al. 2011; Donohue and Levitt 1998.

provide natural experiments that allow me to analyze the impact of the policy on crime and the political process. Using a regression discontinuity design analysis, I study the impact of the legislation on crime rates and on various communities and populations throughout Brazil. I then use a least square regression to examine and compare voter turnout and support for the ban on weapons in neighborhoods that had varying reductions in levels of gun-related violence.

Provisions of the Brazilian legislation present a rare opportunity to identify the effects of a ban on concealed weapons in a way that avoids some of the problems that have surfaced in analyzing the effects of gun legislation elsewhere. Most research on the impact of right-to-carry concealed weapons laws has been conducted in the United States, using variations in state gun legislation to find the impact on crimes. Nearly all of this legislation *expanded* the right to carry concealed weapon. Though extensive research has been conducted, results are inconclusive. Manski and Pepper (2016) explain this phenomenon by showing that empirical findings on the impacts of such laws are highly sensitive to controversial assumptions about crime rates trends. Another shortcoming of this literature stems from endogeneity problems, such as gun regulations potentially enacted in response to crime. The Brazilian law, by contrast, *prohibited* the right to carry concealed weapons, and required people to comply immediately - thus allowing for far better identification of the law's impacts. This contrasts with the situation confronting researchers analyzing the impacts of laws that authorize the carrying of concealed weapons; even if an applicant meets all requirements and seeks a permit for a concealed weapon license right after the law passes, obtaining the permit and the weapon takes time.[2]

[2] The literature on the effects of right-to-carry-concealed-weapons laws is concentrated in the United States, where the time to obtain a license varies from state to state, and from place to place within certain states. For instance, in Florida, the state division of licensing has up to 90 days to review an application for a concealed weapon license, while in Texas, the maximum time allowed to review a license application is 60 days; and within the state of California,

I construct an empirical model that overcomes challenges faced by the literature studying the impact of so-called "right-to-carry" laws on crime. I follow Davis's (2008) empirical strategy of using time as the assignment variable in a regression discontinuity design (RDD).[3] As the law prohibiting the right to carry concealed weapons is a deterministic function of time, there are no confounding variables other than time itself, and endogeneity problems are less of a concern.[4] Moreover, because the same law was imposed on all Brazilian municipalities, there is no need for comparisons between treatment and control groups. This eliminates the need to rely on certain controversial assumptions that have hampered the previous literature.[5]

My results show that prohibiting the carrying of concealed weapons decreased gun-related crimes; the economic value of the law, calculated by using the most conservative measures of the value of statistical life in Brazil, is estimated to be close to $3 billion in one year. Using monthly data (available across the country) on homicides, I find that gun-related homicides decreased by 3,900 (a 10.8 percent reduction) in the year following the law, and that the reduction was most pronounced in high-crime areas; non-gun-related homicides were not affected by the law. Using monthly data on non-homicide crimes at the municipal level, provided by the São Paulo state, I show that the prohibition of the right to carry concealed weapons led to a decrease in robberies,

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the time to obtain a weapon can vary from four months to six months, according to the California Department of Consumers Affairs.

[3] Lucas Davis investigated the impact that restricting automobile usage in Mexico City had on air pollution. For additional examples of empirical strategies using time as the assignment variable in regression discontinuity designs, see: Anderson 2014; Auffhammer and Kellogg 2011; Bento et al. 2014; Busse et al. 2006 and 2010; Gallego et al. 2013.

[4] One problem of measuring the effect on crime from laws that give people the right to carry concealed weapons is dealing with the potential endogeneity of such laws (see Durlauf, Navarro and Rivers 2016).

[5] Manski and Pepper (2016) argue that researchers studying the effects of right to carry concealed weapons laws on crimes in the United States had to rely on strong assumptions such as the assumption that states that enacted right-to-carry-concealed-weapons laws (treatment group) had identical propensities and environments for criminality as those of states that did not enact such laws (control group).

total arrests, and arrests for violations of weapon-carrying laws; non-gun-related crimes such as rape, drug trafficking, and theft remained unchanged.[6]

I use two different empirical strategies to investigate who benefits from the prohibition on carrying concealed weapons, and whether the prohibition impacts social outcomes. Using an RDD, I find that the reduction in gun-related homicides was especially pronounced among young black males, and in places with higher gun-related homicides rates. The regulation decreased gunshots that were categorized as "intending to kill," but did not affect gunshots categorized as "accidental." Using the fact that the prohibition shows heterogeneous effects, I construct a differences-in-differences (DID) model. My treatment group is composed of the population in areas that experienced steeper drops in crime in the wake of the law. The DID, which validates my RDD findings and thus bolsters internal validity, shows that the treatment group higher levels of enrollment in young and adult education, compared to the control group living in less-affected areas.

I then utilize the subsequent referendum, which asked citizens to decide whether to ban all weapons and ammunition, to examine whether places that experienced greater reductions in gun violence are more likely to turn out to vote and to support the gun prohibition. I use an ordinary least-square regression (OLS) and find that areas that had previously had high levels of gun violence and thus had benefitted most from the legislation that prohibited the right to carry concealed weapons had higher levels of voter turnout and higher levels of support for the

[6] Notice that before the prohibition of right to carry concealed weapons, "illegal gun carrying" referred to the unauthorized carrying of open (unconcealed) weapons, but after the prohibition, the carrying of weapons – carrying guns either openly or in a concealed way – was prohibited. São Paulo state is the only Brazilian state to provide monthly data on these types of crimes since 2001. I thank *Secretaria de Segurança do Estado de São Paulo* for sending me these data after a formal request.

referendum on banning guns.[7] These results suggest that people in areas exposed to a greater degree of gun-related violence care more about and show larger support for gun control policies. These findings, combined with the fact that the referendum failed, offer insights about why gun control legislation may be difficult to pass, even though utilitarian welfare gains seem large. Namely, these gains may be concentrated in a small share of the population.

How generalizable are the homicides findings to other countries? While is not possible to know for sure without similar legislature being applied in different contexts, one can hypothesize that laws restricting the number of guns, such as the one applied in Brazil, decrease the number of gun-related deaths.[8] In the Brazilian context, this effect was driven by gun-related homicides, especially the ones committed against young black males living in high-crime areas. Yet, is it possible that in other contexts, gun-related suicides would be affected as well. For instance, Leigh and Neill (2010) show that gun buybacks in Australia reduced gun-related suicides. Additionally, the 10.8 percent reduction in gun-related homicides that I find could be larger in a country in which policing and law enforcement are highly organized and effective, not the Brazilian case.

This paper is divided into six sections as follows. In Section 2, I review relevant literature and explain the gun regulation. In Section 3, I provide an overview of the data and discuss the

[7] In the appendix, I corroborate these findings using a survey that took place two days before the referendum.
[8] The most generalizable finding of this work is on how laws regarding the right to carry concealed weapons affect homicides. Data on non-homicide crimes are provided only by the São Paulo state. This is the most populous and wealthy state of the country, and I do not claim it is representative of Brazil.

empirical strategy. In Section 4, I present the effect of the prohibition of the right to carry concealed weapons on gun-related homicides as well as on other crimes, and on different populations; and I propose a differences-in-differences model to bolster the internal validity of the regression discontinuity design results. In Section 5, I show the connection between benefitting from the 2003 legislation that prohibited the right to carry concealed weapons, and supporting the 2005 referendum in Brazil that proposed banning all firearms. In Section 6, I discuss my results and conclude.

2. Related Literature and the Gun Legislation

2.1 What are the effects of gun laws? Who are their beneficiaries?

There is a vast literature investigating the first question, but no definitive answer to it. Without an answer to the first question, the second one is compromised. The main reason why the first question remains unanswered is because results showing the effects of "concealed carry" laws are sensitive to minor modifications on researchers' assumptions about crime trends. An overview of the literature underscores the difficulties that surface, and the debates that have ensued. Research by Lott and Mustard (1997) reached the controversial conclusion that laws that gave people the right to carry concealed weapons reduced crime rates in the United States.[9] This finding was challenged by Ayres and Donohue (1999 and 2003) and Black and Nagin (1998), on the grounds that the empirical models were not robust to reasonable changes in the model specifications, and that these models were sensitive to the correction of several coding errors. Other studies have showed empirically that concealed weapon laws do not reduce criminality (Duggan, 2001; Ludwig, 1998; Aneja et al. 2011). Aneja et al. (2014) describe a National Research Council panel

[9] Using cross-section panel data at the county level from 1977-1992, their findings showed that approximately 1,500 lives would be saved per year if in 1992 all U.S. states had adopted laws allowing people to carry concealed weapons.

discussion in 2004 that invited specialists to study county-level crime data from 1977-2000 in the United States, and concluded that it was impossible to state whether concealed weapons laws increased or decreased crimes.

Manski and Pepper (2016) explain how authors find contradictory results using similar data and empirical strategies. The authors' answer to this puzzle is that data on crime cannot reveal counterfactual outcomes, which authors commonly solve by making "*invariance* assumptions asserting that specified features of treatment response are constant across space or time (p.3)."[10] Yet, the literature on concealed weapons laws does not find a consensus on credible assumptions regarding crime rates trends. Relaxing invariance assumptions, Manski and Pepper show that there are no simple conclusions, and that it is not possible to identify with certainty the sign of the impact of concealed weapons laws on crime.

Although the literature on the effect of concealed carry laws on crime is inconclusive, many authors find a positive relationship between the number of guns and crimes. However, these findings also face challenges.[11] First, because data on the number of guns available are lacking, proxies are needed. For instance, to proxy for the number of firearms, Duggan (2001) uses the number of gun magazine subscriptions per county, and Cook and Ludwig (2006) use a ratio of gun-related suicides to suicides per county. Second, as Leigh and Neill (2010) point out, such research suffers from endogeneity problems. For instance, people who live in neighborhoods that have higher crime rates might buy more guns to protect themselves. Therefore, gun ownership could be related to current crimes or expectations of future crime rates.

[10] The following case illustrates an example of an invariance assumption: Virginia enacted law conferring the right to carry concealed weapon in 1989, but Maryland did not. Then, assume that in the absence of such law, Virginia and Maryland would experience the same changes in crimes between 1988 and 1990.

[11] See Cerqueira and Mello 2013; Duggan 2001; Stolzenberg and D´Alessio 2000, McDowall 1991; Cook and Ludwig 1998, 2002, 2006; and Newton and Zimring 1969.

In a study of a gun buyback program in Australia, Leigh and Neil (2010) used a comparison of the differences in the number of firearms surrendered in different states to show that gun-related suicides decreased by 80 percent due to this program (the effects on gun-related homicides were less precise). Nonetheless, their work has the same problem as the ones that studied the impact of concealed weapon laws in the United States. That is, the research assumes that all Australian states would have had the same gun-related death changes if they had bought back the same number of guns. It also relies on the assumption that the buyback rate in each state had no relationship with pre-existing trends.

The endogeneity problem faced by research examining the impact of concealed carry laws on crime, as well as the relationship between guns and crime, is not easily addressed. These studies need to rely on assumptions that pre-existing annual crime trends do not affect gun ownership, the implementation of anti-crime policies, or the effectiveness of these policies. This work, however, uses monthly data on crime and the enactment of legislation that prohibited the right to carry concealed weapons to construct an RDD model that overcomes both the endogeneity problems and the reliance on strong assumptions. The advantage of using an RDD model is that restricting the window of time addressed by my analysis enhances the credibility of the assumption that the only differences in crimes trends after the concealed weapon prohibition take place in response to the law.

Although effects of concealed carry laws are inconclusive, scholars agree that their impact might be sensitive to different environments. For instance, Duggan (2001) and Durlauf et al. (2016) believe that the underlying environments as well as rates of gun ownership and criminality can explain such laws' effects. The literature on gun prevalence and crimes sustain such an argument. Cook and Ludwig (2004) find that the prevalence of youths carrying guns is positively related to

local rate of youth violence. They also find that blacks and Hispanics are more likely to carry a gun than others. Cook and Ludwig (2006) show that gun ownership is linked to higher rates of homicides, and this effect is accentuated in youth homicides. After identifying the effect of the concealed weapons prohibition on crime, I also investigate whether these effects vary according to race and age of victims of gun-related homicides, and to the level of gun violence in the municipality.

2.2 Legislation prohibiting the right to carry concealed weapons and the referendum on a ban on all weapons and ammunition

Brazilian legislation barred the carrying of concealed weapons, and provided for a voter referendum on whether to ban weapons 22 months after the legislation's enactment. The former provision of the act allows me to measure whether prohibiting gun carrying decrease crimes, and the latter provision can help to establish a relationship between being affected by gun laws and showing support for them.

In the early 2000s, as Figure 1 illustrates, more than 30,000 gun-related homicides occurred in Brazil every year, and most of the victims were young.[12] This number was much smaller in the 1980s but sharply increased in the 1990s. Although 60 percent of the victims of gun-related homicides were young (15-29 years old), this population only represented close to 30 percent of the population. The number of gun-related homicides per 100,000 people for this age group increased from 27.6 in the 1990 to 42.2 in 2000 – while the number of gun-related homicides per 100,000 people for all ages rose from 14.3 to 20.6. Therefore, the sharp increase in gun-related homicides in Brazil in the 1990s disproportionately affected young people.

[12] Yearly data from 1979 to 2013 are available at DATASUS (data from Brazilian Health Ministry).

Motivated by this dramatic increase in the number of firearm-related deaths in Brazil, legislators passed nationwide firearm regulations in December 22nd, 2003 (Law number 10.826), in the form of the *Estatuto do Desarmamento* (Disarmament Statute). The legislation prohibited citizens from carrying a gun outside of their residences or places of business; it provided exemptions for hunters (sporting or subsistence), private security employees, and police officers. The penalty for illegal possession (or carrying) increased from an incarceration period of one to three months, to two to four years.[13] Finally, the statute made obtaining a gun permit more expensive, and imposed more stringent requirements that made the process more restrictive.[14] This package of measures was enacted to decrease gun violence.

An important and unique feature of the legislation was its 35th section, which set the stage for a national referendum to take place in October 2005 (22 months after the initial legislation was passed into law), to allow Brazilian citizens to vote on an even more restrictive weapons laws. The law put forward in the referendum stipulated that the sale of any guns and ammunition would be completely prohibited in the country (again, with exceptions for hunter and those with security-related jobs). More specifically, voters were asked the following question: Should the commerce of firearms and ammunition be prohibited in Brazil? Therefore, the referendum did not propose to change the previously passed legislative statute, which that prohibited the carrying of concealed weapons, but it proposed to go further, by prohibiting the sale of all firearms. In what follows, I describe the referendum campaign and its outcome.

[13] This penalty is harsher than most of the ones applied in the United States, where most states punish possession of gun without permit as a misdemeanor. For instance, in New York, possession without permit is punishable by up to one year in prison, a fine of up to $1,000, or both

[14] An applicant should have no criminal record, be employed, show proof of residence, pay a fee close to $1,000 attend a gun safety course, and pass a psychological exam.

As argued by De Vreese and Semetko (2004), political campaigning is more relevant in referendums than regular elections, especially because heuristics (e.g. ballot cues) are absent and political parties' attitudes may confuse voters. In the 2005 Brazilian referendum, the two main opposing parties in the political arena, the Workers Party (PT) and the Brazilian Social Democracy Party (PSDB), supported the campaign in favor of prohibiting the sale of guns. At the same time, the Liberal Front Party (PFL, an extreme right-wing party) worked together with the United Workers Socialist Party (PSTU, an extreme left-wing party) against the gun ban. The mixed signals coming from parties' political ideologies can explain why voters could not rely on typical political cues, and why the political campaign, conducted mostly through TV ads, gained importance.[15]

The campaign against the gun prohibition used exploitation of fear as its most effective argument against the referendum's proposition.[16] The televised advertisements argued that the inability of the Brazilian state to provide security would leave citizens defenseless against criminals if firearms were banned.[17] For instance, as noted by Lissovsky (2006), the second most televised ad of the campaign against the gun ban, which aired 38 times during three consecutive days,[18] showed a citizen (representing a family man) placing a sign at his front door informing passersby that he did not possess any weapons. After the man installed the sign and admired his work, the soundtrack becomes dark. It becomes clear to the audience that he immediately regrets his decision. Consequently, he removes the sign while the speaker concludes: the problem is not

[15] The government provided one hour daily (each side had half hour) of free electoral airtime on free-to-air television (all radio stations broadcast it simultaneously). In addition, each side had short TV ads available to them during the day.
[16] See Anastasia, Inacio and Novais 2006; Araújo and Santana 2006; Inacio 2006; Lissovsky 2006; Mota 2006; Cunha 2006; Esteves 2007; Goldstein 2007; Veiga and dos Santos 2008; Cavalcanti 2016.
[17] Cunha (2006) argues that vulnerability, sense of fear and uncertainty were the most common themes explored by the campaign against the gun ban, particularly during the last 10 (out of 20) days of campaign.
[18] These dates, October 15-17, are close to the last day of campaign, which was held on October 20, 2005.The timing suggests the relevance and appeal of the message.

for me not to have a gun; the problem is that the criminal will know for sure that I do not have one.[19] This exploitation of fear created uncertainty about citizen security in a should the referendum succeed; this led many to vote in favor of the status quo.

Moreover, the campaign against the gun sale prohibition, as Lissovsky (2006) characterizes it, was well organized, had twice as much money,[20] and promoted a main message that was direct and focused: Prohibiting guns was an attempt of suppression of rights (even though possessing guns was never a constitutional right in Brazil as it is in the United States), which would increase citizens' vulnerability to crime. In addition, Cavalcanti (2016) argues that the National Rifle Association (NRA) provided the campaign against the gun ban with financial means and expertise.[21] It provided the campaign with strategic advice and propaganda materials that were previously used in the United States.

By contrast, the campaign in favor of the gun ban was supported by researchers and criminologists. However, as Soares (2006, p.75) argues, "(…) that tremendous and cognitive and factual advantage was not transformed into a political and electoral advantage." The most problematic issue with this campaign was its lack of organization. As Mota (2006) argues, one of the main coordinators of the campaign in favor of the gun prohibition, Ruben César Fernandes, admitted that he had no specific strategy. Another mistake, according to Mota (2006), was the usage of celebrities to deliver the campaign message. Common citizens' testimonies reporting their daily struggles with gun-related homicides might have better connected with the audience. For all of these reasons, it seems clear that the campaign against the gun ban was better organized than

[19] This advertisement can be accessed at: https://www.youtube.com/watch?v=Nu4okj8yPws
[20] The campaign against gun ban was financed by the gun industry and got $2 million, while the campaign in favor of gun ban got $960 thousand.
[21] The author claims that the NRA should be interested in the referendum because if the gun ban passed and provided evidence that the society was better after it, many other countries could attempt to do the same.

the campaign in favor of it, and these differences in campaign capabilities can help to explain the referendum's final outcome, in which 64 percent of the population voted against the gun ban. In section 5, I establish a link between voter support for the prohibition on the sale of firearms and the effectiveness of the earlier legislation that prohibited carrying concealed weapons; this link, which has been neglected by the literature thus far, can provide insights about which voter types believe they benefit from gun control legislations.

3. Data and empirical strategy

3.1 The impact of prohibiting the carrying of concealed weapons, and who benefits from it

I begin my study of the effects of the prohibition against carrying concealed weapons on homicides, and then I examine its effects on non-homicide crimes. Monthly homicide data at the municipality level have been available across the country since 1996 in the Brazilian National System of Mortality Records (DATASUS). Monthly data on non-homicide crimes are only available for the state of São Paulo provided by the *Secretaria de Segurança Pública de São Paulo* since 2001. Table 1 shows descriptive statistics, considering the year of 2003, of homicides in Brazil and non-homicide crimes in the state of São Paulo. Brazil had 36,115 gun-related homicides in this year (which rendered it the country with the largest annual number of gun-related homicides in the world). In Brazil, 70 percent of all homicides are gun related homicides. Theft is the most common crime in the state of São Paulo, followed by robbery. Robberies, in contrast to thefts, involve criminal and victims' interaction with force, intimidation, and/or coercion, so criminals often use guns in these situations. Therefore, if the concealed carry ban were effective, one would expect gun-related homicides, robberies and illegal gun carrying to be more affected than other non-gun-related crimes.

Following Davis (2008), I use an RDD where time is the forcing variable to evaluate the impact of the concealed carry prohibition on crimes.[22] This method, also known as an Interrupted Times Series (ITS), has been widely used to estimate the effects of policy changes (Gonzalez-Navarro 2013; Moscoe et al. 2015; Bernal et al. 2017). As Moscoe et al. (2015) argue, ITS can be interpreted as a sub-type of RDD, in which time is the assignment variable, and the cutoff is defined as the date when a new policy is implemented.

Bernal et al. (2017) make a tutorial on when and how to use an ITS. They argue that this methodology is validated when the expected trend of the variable of interest, in the absence of the intervention (i.e. calculated using pre-intervention data), should be different than the one observed once the intervention is enacted. At the same time, the conditional expectation of confounding variables that can affect the variable of interest must be continuous around the intervention. Figure 2 shows satisfaction of this requisite. Gun-related homicides deviate from the trend after the prohibition of the right to carry concealed weapons. In contrast, non-gun-related homicides, which captures potential confounding variables related to crime that could be changing simultaneously with the law, follow the trend predicted using pre-intervention data and are continuous around the cutoff (January 2004).[23] This mitigates concerns of endogeneity problems.

Studies examining crimes usually restrict their sample because of few occurrences. For instance, Cerqueira and Mello (2013) study the impact of a gun law on crimes in the state of São Paulo. They use as the dependent variable the annual change in the number of gun-related suicides to total suicides, and argue that this variable is noisy in small municipalities because of low

[22] For additional examples of empirical strategies using time as the assignment variable in regression discontinuity designs, see: Anderson 2014; Auffhammer and Kellogg 2011; Bento et al. 2014; Busse et al. 2006 2010; Gallego et al. 2013.

[23] As I only have access to monthly data, I defined January 2004 as my cutoff point. However, the last eight days of December 2003 are contaminated because the gun prohibition was already in effect. Nonetheless, if anything, this fact would underestimate my results.

incidence. Therefore, they consider only municipalities with more than 50,000 inhabitants. Cook and Ludwig (2006) use a similar strategy and consider only the 200 counties with the largest populations in the United States. Because the number of homicides is not as uncommon as suicides, I consider municipalities with more than 10,000 inhabitants.[24]

My empirical model is constructed as the following least square estimation:[25]

$$GRH_{mt} = \alpha + \lambda D + \beta_1(r-c) + \beta_2(r-c) * D + X_{mt} + \Lambda_m + \epsilon_{mt}, \quad (1)$$

such that: $(c-h) \leq r \leq (c+h)$

where GRH_{mt} is the number of gun-related homicides per 100,000 people at municipality m at month t, c represents the cutoff, r indicates the months surrounding the cutoff, D is a dummy indicating that the prohibition of right to carry concealed weapons became effective, and h represents the selected bandwidth (in months). λ is my main independent variable, which captures the law effect. X_{mt} contains monthly data for temperature and rainfall accumulation for each municipality m at month t.[26] Λ_m are dummies indicating each calendar month to capture any seasonal effect.[27] Finally, ϵ_{mt} contains the error term for each observation.

Using population and gunshot wounds data, I verify whether the prohibition of right to carry concealed weapons had heterogeneous effects, and whether its effects were driven by

[24] Municipalities with more than 10,000 inhabitants account for 92.4 percent of the total Brazilian population; nearly all, 98 percent, of gun-related homicides occur in these areas. I show in the Appendix (Table A1) that choosing different threshold options (50,000 and 100,000 inhabitants) does not change my results.

[25] I do not add municipal fixed effects because, as Lee and Lemieux (2010) argue, including fixed effects is unnecessary for identification in a RD design. Nonetheless, it is important to highlight that including fixed effects does not significantly change the results as reported in the appendix.

[26] I control for monthly rainfall and temperatures because researchers have demonstrated that weather is related to crime (see Cohn, 1990 for a review of this literature). Monthly rainfall and temperature data were collected from Matsuura and Willmott (2009). The authors provide estimations of monthly worldwide precipitation and temperature data at the 0.5 x 0.5 degree level. Each point is characterized by a specific geographic coordination (latitude and longitude), and the monthly precipitation and average temperature for each point is associated with the rainfall and temperature data collected from its 20 closest weather stations.

[27] In Brazil summer starts in December and ends in March. As showed by (Waisekfisz and Athias (2005) – Mapa da Violência SP), the number of homicides reaches its peak in the summer.

intentional gunshots. Using the RDD strategy proposed, I split the sample among different races and age of victims of gun-related homicides to study the law's effects on various populations. Then, using data on gunshot wounds, provided by the DATASUS, I examine whether gunshot wounds intended to kill were affected to a greater degree than accidental ones.

I then examine if the effects of the concealed carry prohibition are larger in places having more youth that are vulnerable to becoming criminals. Young people are overrepresented as both victims and perpetrators of violence, and the likelihood that someone carries a gun is larger in places with higher rates of youth violence and among high-risk groups (Cook and Ludwig 2004). I construct an index, at the municipality level, which I call the *vulnerability index,* to measure youth violence. I then assess whether the effects of the law that prohibited carrying concealed weapons varies in accordance with such an index.[28]

To measure how the vulnerability index relates to the law effects, I build on equation (1) and construct the following RDD analysis:

$$GRH_{mt} = \alpha + \lambda D + \beta_1(r - c) + \beta_2 vuln.index_m + \beta_3 vuln.index_m * D + X_{mt} + \Lambda_m + \epsilon_{mt}, \quad (2)$$

where β_3 is now my main coefficient of interest. It measures whether the effectiveness of the prohibition on carrying concealed weapons is related to the $vuln.index_m$ (vulnerability index in municipality m). My analysis indicates that there are heterogeneous effects of the law.

Lastly, I use a DID to validate my RDD findings in equation (2). Taking advantage of how the law's effects vary in accordance with the vulnerability index, I propose the following DID estimation:

[28] Further details about this index is provided in section 4.

$$GRH_{mt} = \alpha + \beta_1 Post_t + \beta_2 Post_t * vuln.index_m + X_{mt} + \Lambda_m + \epsilon_{mt}, \quad (3)$$

where $Post_t$ is a dummy variable equal to one when $t = 2004$ (and equal to zero when $t = 2003$), $vuln.index_m$ is the vulnerability index in municipality m discussed above. Vector X_{mt} includes control variables that vary across time and municipalities. The dependent variable GRH_{mt} corresponds to the gun-related homicides in municipality m and year t.[29] Λ_m represents municipal fixed effects and ϵ_{mt} is the error term. The coefficient β_2 is the parameter of interest that captures the effect of the prohibition of carrying concealed weapons on gun-related homicides.

3.2 Do places with larger reductions in gun violence show stronger support for the referendum banning gun sales?

To answer this question, I examine the Brazilian 2005 referendum proposing a prohibition on the sale of all firearms and ammunition. My dependent variables are the percentage of votes in favor of the prohibition, as well as the turnout-to-registered-voters' ratio. These data are available from the Brazilian Superior Electoral Court (TSE). The control variables are collected from both IBGE and IPEADATA. They are composed of socioeconomic and demographic data.[30] I also control for variables that are especially relevant in the literature on support for gun control.[31]

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[29] Using the DID methodology I can access whether the prohibition of the right to carry concealed weapons impacted educational outcomes. More specifically, I test whether places with higher vulnerability indices had a relatively larger young and adult education enrollment (i.e. young and adult education enrollment is my dependent variable in equation 3).

[30] More specifically, the control variables are mostly collected from the 2000 census and are composed by: the ratio of the number of women to the number of men, per capita GDP (in 2005), total population (in 2005), percentage of people living in rural areas, years of schooling, percentage of households with TV access, the ratio of the number of households receiving government conditional cash transfer (Bolsa Família) to total population, distance to the state capital (which in Brazil is the main city in the state in terms of GDP and population), change in the income distribution (between 1991 and 2000), number of cattle per people living in rural areas, and the ratio of government-initiated agricultural land distributed to total agricultural land.

[31] For a discussion on why people support gun control, see Esposito and Finley, 2014; Carlson, 2012; Neiva, 2010; Kleck, Gertz and Bratton, 2009; Grafton and Permaloff, 2005; Kleck, 1996; Ellison, 1991. I included an index that measures the political ideology of the municipality (Schneider, 2016). I also included a dummy indicating land reform protest within a year of the referendum [source: Lab of Agriculture Geography (LAGEA)]. This is an important variable because farmers use guns to defend themselves against land invasions. Finally, I included a dummy indicating

However, my main independent variable is the vulnerability index. Because places with higher vulnerability indices were disproportionately affected by the prohibition on carrying concealed weapons, I can examine whether places that benefited most from the 2003 legislation had larger turnout and demonstrated higher levels of support for the referendum.

I propose the following OLS regression to test the impact of policies on politics:

$$Y_m = \alpha + \beta_1 vuln.index_m + X_m + \Lambda_s + \epsilon_m, \quad (4)$$

where Y_m is the dependent variable in municipality m and can be both the percentage of the vote in favor of the prohibition as well as the turnout-to-registered-voters' ratio. The vector X_m includes all control variables relevant to explain support for gun control. Λ_s represents state fixed effects and ϵ_m is the error term. The coefficient β_1 is the parameter of interest that captures the effect of the policy on the dependent variable. As I show later, the $vuln.index_m$ variable explains the effectiveness of the prohibition on carrying concealed weapons and should, therefore, be related to political outcomes associated with the referendum.

4. Analyzing the effects of the concealed carry prohibition on crime, and determining who benefits from the law

I first investigate the impact of prohibiting the carrying of concealed weapons on crime, and then I show who benefits the most from the law. I focus on homicides because data on this type of crime are available across the country. Using population data, I investigate which groups were more affected by the concealed carry prohibition. Finally, I validate my RDD findings using a DID model, which also allows me to study whether places that experienced greater benefits from

drought within one year of the election [source: Integrated System of Disaster Information (S2ID)]. Drought may increase landless peoples' propensities to invade land (see, for instance, Ralston 2013).

the law had a greater proportion of youths in the population and whether these areas experienced any changes in enrollment in adult education programs.

4.1 The effects of the law prohibiting carrying concealed weapons on gun-related homicides

Using the regression proposed in equation (1), I estimate the impact of the law on total homicides, gun-related homicides and non-gun-related homicides. Following Davis (2008), I show on Figure 3 a graphical result considering an eight-year window around the treatment start date. This figure indicates that the reduction in homicides that followed the prohibition on carrying concealed weapons was driven by gun-related homicides. Table 2 reports results considering the selection of different bandwidths, and suggests that the short-run effect of the law was larger than the long-run effect. Before proceeding further with Table 2 analysis, it is important to comment on two facts. First, gun-related suicides were only marginally affected by the law that prohibited the carrying of concealed weapons.[32] Second, not taking seasonality into account decreases the magnitude and significance of the gun-related homicides coefficient, suggesting that seasonality plays an important role: the decrease in gun-related homicides in January, a month in which this variable would usually reach its annual peak, shows the strength of the law.

The results on Table 2 shows a strong relationship between the law and gun-related homicides. Column 3 of the first row indicates that the legislation decreased the monthly gun-related homicides per 100,000 people by 0.191 on average.[33] In 2003, Brazil had 167,546,532

[32] The coefficients measuring the impact of prohibiting carrying concealed weapons on gun-related suicides was -0.025, and the standard deviation was equal to 0.0145. This result contrasts with the findings of Leigh and Neil (2010) showing that the gun buyback in Australia reduced gun-related deaths, but mostly as a result of a sharp decline in suicides. However, it is important to point out that in Brazil, different from Australia, gun-related suicides are rare events that represent just 3 percent of total gun-related deaths.

[33] The mean of monthly gun-related homicides per 100,000 people mean is .75, and the standard deviation is 2.

people living in municipalities with more than 10,000 inhabitants, so close to 3,900 lives were saved in 2004 due to the implementation of the law, which corresponds to 10.8 percent of the total gun-related homicides in 2003.[34] This result is close to the one found by Waisekfisz (2016) using a linear trend of gun-related homicides in Brazil between 1997-2003.[35] Extending the window of my analysis, as shown in the second and third rows of Table 2, attenuates the effects of the law on gun-related homicides to an annual reduction of 6.7 percent. This result suggests that the law had a larger effect in its first year; however, it also indicates that the gains provided by the concealed carry ban did not vanish within those years. In the appendix (Table A1), I show that the estimations are not sensitive to model specifications.

As a robustness check, I present a falsification test where I simulate different dates for the beginning of the gun control regulation. Table 3 shows coefficients estimated from these simulations. The only significant result is obtained when I consider the correct date in which the prohibition of concealed carry took effect, i.e., January 2004.

4.2 What is the effect of the concealed carry prohibition on other crimes?

To answer this question, I use monthly data on non-homicide crimes that are provided by the state of São Paulo only.[36] I find that robbery, illegal gun carrying and total arrests were reduced while rape, drug trafficking and theft remained unchanged.

[34] I obtained this number by multiplying 0.191 by 12 to get an annual measure. Next, I multiplied the outcome by 167,546,532 and divided by 100,000.

[35] Waisekfisz (2016) indicated that there should have been 4,391 more gun-related homicides in Brazil in 2004 than the number that were reported, and he attributed this positive impact to the gun-control legislation. My estimation, however, controls for weather and seasonality effects, uses monthly data at the municipality level, and examines a much shorter period than in Waisekfisz (2016) to overcome my inability to control for important economic and social changes that can affect my dependent variable.

[36] In Brazil, each state is responsible for providing its own public security. São Paulo is the only state to provide monthly data on crime since 2001.

Figure 3 shows the impact of the law on five crimes plus total arrests, which are: illegal gun carrying, drug trafficking, rapes, robbery and theft. As one can notice, the concealed carry prohibition decreased the number of crimes related to guns as well as total arrests.[37] The monthly data show illegal gun carrying per 100,000 people decreased by 0.94 (26 percent% reduction); robberies per 100,000 people decreased by 5.52 (7.7 percent); and arrests per 100,000 people decreased by 3.37 (16 percent reduction).[38]

I find evidence that the concealed carry prohibition affects gun-related crimes, but does not change the remaining (non-gun-related) crimes, indicating that the law inhibited criminals from carrying guns. These results should be interpreted with care as the sample covers only São Paulo state. I do not claim that São Paulo is representative of the entire country: it is a relatively rich state (largest GDP and second largest GDP per capita) and the most populous of Brazil. Nonetheless, it can provide some insights about the entire country, especially because the state of São Paulo had a similar reduction in gun-related homicides (9.91 percent) as observed for whole sample.[39] Next, I return to the data on gun-related homicides and expand my analysis to Brazil to investigate the conditions explaining the effectiveness of the concealed carry prohibition.

4.3 Who benefits the most from prohibiting the right to carry concealed weapons?

I propose a demographic division to better understand which population group benefitted the most from the concealed carry prohibition. I use the same RDD proposed in equation (1), but split gun-related homicides by age and race of victims. Before showing the results, I present

[37] Robbery, in contrast to theft, involves criminal and victims' interaction with force, intimidation, and/or coercion. As a result, criminals often use guns in these situations.
[38] Using a falsification test where I define the cutoff to be January 2003, I find no effects for illegal gun carrying, robberies and total arrests.
[39] This result is available upon request.

descriptive statistics in Table 4. It shows the number of gun-related homicides in 2003 divided across race and age.[40]

The reduction in gun-related homicides was especially pronounced among young black males. Table 5, Panel A, shows that the effect on gun-related homicides is driven by blacks. Although *only* 56 percent of the victims of gun-related homicides are blacks (Table 4), the effects of the concealed carry prohibition surface almost exclusively among this segment of the population. Waisekfisz (2012) performs an analysis of homicides victims in Brazil by race. The author argues that blacks, compared to whites, are disadvantaged in terms of education, income, and security, and that they are the main victims of violent crimes. Therefore, my results indicate that the concealed carry prohibition was more effective in areas that lack security, and have high rates of crime. Panel B of Table 5 suggests that young people (between 15 and 29 years of age) experienced greater benefits from the law; however, this should be expected because this group represents the majority of the victims of gun-related homicides (Table 4).

Table 5 indicates that the effect of the prohibition of carrying concealed weapons is related to crime rates. To test this hypothesis, I split off the sample between quartiles according to the distribution of gun-related homicides per 100,000 residents between 1996 and 2003. As Table 6 shows, the effects of the concealed carry prohibition are driven by the last quartile that splits off the highest 75 percent of municipalities according to gun-related homicides rates. Therefore, the effects of the concealed carry prohibition were pronounced among young black males living in crime-ridden areas. Next, I use hospitalization data to investigate the effect of the law on gunshot wounds.

[40] I chose not to focus on gender because most of the victims of gun-related homicides are male (about 94 percent of the total).

The subsequent analysis investigates data on monthly gunshot wounds at the municipality level, which are classified as "accidental" or "intended to kill." As gunshot wounds happen less frequently than gun-related homicides (in 2003 there were 21,484 gunshot wounds), I restrict my sample to municipalities with more than 50,000 people.[41] Table 7 presents an RDD estimation showing that only the gunshots intended to kill were affected by the law. My estimation indicates that the law caused a reduction of 11.6 percent in the total gunshot wounds in the "intended to kill" category. This is additional evidence that prohibiting the carrying of concealed weapons affects victims of murder instead of victims of involuntary manslaughter.

4.4 The vulnerability index

To investigate the previous subsection indication that high-crime areas disproportionately benefitted from the law, I construct an index considering the level of at-risk youth in each municipality.[42] The goal of this index is to map the places that have more young people susceptible to becoming criminals. They, and the people living close to them, are more likely to be exposed to gun-related homicides. The index I construct is based on the index of vulnerable young people developed by the SEADE Foundation (State System of Data Analysis) for the São Paulo city neighborhoods.[43] Formally, the index is constructed as follows:

[41] The decision to restrict the sample to municipalities with more than 50,000 people results in analysis of 65 percent of the Brazilian population, but that group includes 98 percent of gunshot wounds intended to kill and 93 percent of accidental gunshot wounds. The results are still significant, but less precise, if I consider municipalities with more than 10,000 people (92 percent of the total Brazilian population).

[42] Here, at-risk youth measures how unlikely young people are to avoid a life of crime.

[43] See http://produtos.seade.gov.br/produtos/ivj/

$$vulnerability\ index_m = \frac{\sum_{i=1}^{5}\left(\left(\frac{var_{mi}-Min(var_i)}{Max(var_i)-Min(var_i)}\right)*100\right)+\left(100-\left(\frac{var_{m6}-Min(var_6)}{Max(var_6)-Min(var_6)}\right)*100\right)}{6} \quad (5)$$

where i represents the six variables described in Table 8.[44]

The decision to use such an index finds support in the literature. As Cook and Ludwig (2006) argue, young people comprise "a relatively high percentage of whom are killed in gang- and felony-related attacks by youthful criminals" (p.387). Young people are also overrepresented as the victims of gun-related homicides in Brazil (Figure 1), and they experienced more pronounced effects from the prohibition on carrying concealed weapons (Table 5). Also, by considering homicide rates, this index captures the effect presented in Table 6 showing that the law disproportionately benefitted high-crime areas. Thus, prohibiting the carrying of concealed weapons should disproportionately affect gun-related homicides in places with higher vulnerability indices.

Next, I show that the number of gun-related homicides disproportionately decreased in places where the vulnerability indices were larger. Table 9 uses the RDD proposed in equation (2) and finds that an increase of one unit in the vulnerability index intensifies the effect of the concealed carry prohibition by additionally reducing the annual gun-related homicides by 221. Therefore, the law provided more benefits to areas with higher levels of youth violence.

4.5 Bolstering internal validity with a difference-in-differences (DID) model

The previous subsection shows that gun-related homicides disproportionately decreased in high-crime areas. This conclusion allows me to validate my RDD findings using a difference-in-

[44] This index hypothetically ranges from zero to 100. However, the minimum and maximum values are respectively 11.49 and 58.32. Its average equals 32.10, and standard deviation equals 5.

differences model, where the treatment group is composed of areas with higher vulnerability indices areas (the regions that were more affected by the law).

Strong internal validity is a great advantage of RDD models. However, one common criticism of the methodology is that internal validity is obtained at the expense of external validity. One feature of my analysis helps mitigate this concern: namely the fact that many municipalities (2,875) had more than 10,000 people, and so my sample contains 51.6 percent of Brazilian municipalities. In addition, to demonstrate the robustness of the findings, I estimate the DID proposed in equation (3).

Table 10 presents the results showing that an increase of one unit in the vulnerability index intensifies the law's effect by additionally reducing the annual gun-related homicides by 244. The estimated coefficient (β_3) is very close to the one estimated in Table 9, bolstering the internal validity of the RDD estimates. Taking advantage of this DID strategy, I show next an analysis using annual data on school enrollment as the dependent variable to check if there is any indication of larger school enrollment of young males in high-crime areas.

4.6 School Enrollment

The empirical evidence presented thus far indicates that young black males living in high-crime areas were disproportionately affected by the legislation. This group should, therefore, be participating more in alternative activities such as education. Using data of the *Censo Escolar* (Brazilian school census),[45] I find empirical evidence that male enrollment in adult education increased more in high-crime areas after the concealed carry ban took effect. Adult education is a public program focused on giving young adults who dropped out of or never attended school the

[45] Data for the Censo Escolar (Brazilian school census) can be found at: http://portal.inep.gov.br/censo-escolar

opportunity to finish their basic studies. In 2004, 63 percent of people enrolled in this program were between ages 15 and 29 (85 percent were between ages 15 and 39). Though collection of race-related data only began in 2005 − thus preventing a racial analysis, given my time window − the initial information from 2005 indicates that blacks used adult education more than other races; among the male students who declared their race, 67.4 percent were black.

Figure 5 illustrates my argument; it shows that male enrollment in adult education increased disproportionately more in places with an above-median vulnerability index (treatment group), while female enrollment did not change. I use female enrollment as a placebo because women are almost unaffected by gun-related homicides (94 percent of such victims are male). Schools release enrollment figures annually, at the beginning of the year. Therefore, the year 2005 captures the effect of the concealed carry ban at a time when the law had been in place for about a year.

Table 11 tests the significance of the results using the same methodology proposed in equation (3), but using enrollment in adult education per 100,000 people as the dependent variable. It shows that an increase of one unit in the vulnerability index amplifies the effect of the concealed carry prohibition on male enrollment by increasing it by 6.5 enrollments per 100,000 inhabitants.

To conclude, the main result of section 4 is that prohibiting the carrying of concealed weapons reduces gun-related homicides and that high-crime areas disproportionately benefitted from the regulation. In the next section, I show that high-crime areas were also more likely to turnout to vote in the referendum and to support the gun prohibition.

5. Policy feedback: the 2005 Brazilian referendum case

This section investigates whether areas that benefitted most from the concealed weapon-carrying prohibition had higher voter turnout and had greater levels of support for the subsequent referendum banning all firearm sales in Brazil I test this hypothesis using the regression proposed in equation (4). Places with high vulnerability indices disproportionately benefitted from the law; thus, I expect these places to have higher voter turnout, and for voters to show more support for the gun prohibition referendum.

As mentioned before, the vulnerability index was originally constructed to measure young people's vulnerabilities to crime in the neighborhoods of the São Paulo municipality. As São Paulo is the largest city of Brazil, the Superior Electoral Court makes electoral neighborhood-level data available for the São Paulo municipality. Taking advantage of these neighborhood-level data, Figure 6 presents the estimated relationship between voting in favor of the gun ban and the vulnerability index, after adjusting for income and population. As expected, the relationship is positive and strong. Next, I show that this relationship also exists across the country.

Table 12 presents an OLS regression using the vulnerability index to explain the vote in favor of the prohibition (equation 4). I find a positive relationship between vulnerability index and support for gun prohibition. The coefficient estimated in column 1 is remarkably close to the one estimated for the São Paulo city's neighborhoods (Figure 6); even after all control variables are added to the model, as Column 2 presents, the estimated vulnerability index impact remains close to the one estimated for São Paulo city's neighborhoods. One way to interpret the vulnerability index coefficient is to compare municipalities with the "best" and "worst" indices.[46] In moving from a municipality with the "best" index (11.49) to a municipality with the "worst" index (58.32),

[46] The "best" index in this context means that the municipality had the lowest vulnerability index, and the "worst" had the highest vulnerability index.

the likelihood of voting in favor of the prohibition increases by 12.27 percentage points. This is a relevant number as an increase of 13.94 percentage points for the "Yes campaign" would have been enough for the proposed weapons ban to win.

Although my estimations provide strong and expected results, they may suffer from omitted variable bias, especially due to the lack of control for the number of guns in the municipalities. This could explain the significance of the results. For instance, it could be the case that places without gun-related homicides are also places where many citizens have firearms and where firearms serve as a deterrent to violence.[47] To address this potential omitted-variable problem, I collect municipal data on the number of unlawful gun firings and unlawful gun carrying after the law's passage to serve as a proxy for the number of guns in the municipality.[48] Unfortunately, these data are only available for the state of São Paulo. As Column 3 of Table 12 shows, the number of guns in the municipalities is not driving my results. Once again, the vulnerability index coefficient remains close to those estimated for São Paulo's neighborhoods and the whole country. This confirms my previous results, and I further validate them in the appendix.[49] Next, I discuss the effect of the vulnerability index on voter turnout.

Before investigating the effect of vulnerability index on the turnout-to-electorate ratio, I discuss the turnout bias introduced by mandatory voting in Brazil. As Cepaluni and Hidalgo (2016) argue, in Brazil, a compulsory voting system increases inequality in turnout. The participation gap between poorer and wealthier voters is heightened by the Brazilian compulsory voting system

[47] This argument is assessed through a model of crime in Donohue and Levitt (1998).
[48] This data are aggregated by year, at the municipal level. The year considered in the sample is 2004.
[49] I use a survey that took place two days before the referendum to corroborate my argument that people who were more likely to benefit from the concealed weapon ban (i.e. people more exposed to gun violence) showed greater support for weapons ban (Tables A2). I also present in the appendix (Tables A3 and A4) an analysis showing that the closer to the referendum that a gun-related homicide takes place, the more it positively affects support for the gun ban.

because nonmonetary penalties for abstention disproportionately affect middle- and upper-class voters. Therefore, they turnout more to vote. As examples of these nonmonetary fines, the authors mention prohibiting violators from obtaining a passport and/or taking a civil service exam − services that are primarily used by members of middle and upper classes.

As a higher vulnerability index is associated with poverty, and voting turnout is biased toward upper classes, a negative relationship between this index and turnout should be expected. To solve this problem, I include the previous turnout-to-registered-voters' ratio (turnout in the 2004 elections) and interact this variable with the vulnerability index. Table 13 presents the results. As one can notice, given a certain level of the 2004 turnout-to-registered-voters' ratio, an increase of one unit in the vulnerability index increases voter turnout for the referendum by 1.3 percentage points, indicating that people living in areas with larger reductions in gun violence care more about gun-control policies.[50]

6. Discussion and conclusions

Many countries have gun regulations, and measuring their impact is both important and extremely difficult. Laws that give people the right to carry guns are the most-studied gun regulations (Leigh and Neil, 2010). Nonetheless, as Manski and Pepper (2016) argue, it is not possible to make any conclusions about the effects of such laws without making strong assumptions. Showing that different assumptions lead to different conclusions about the impact of gun laws on crime rates, they conclude by saying "…we do not report findings with incredible certitude: there are no simple conclusions." However, certain aspects of Brazil's gun legislation

[50] In the appendix I show (Table A2) that people who would have voted in the referendum even if voting were not mandatory were more likely to support the gun ban.

allow one to circumvent problems that have plagued other natural experiments, and, thus, allow for a window onto the issue that offers clearer insights and conclusions.

This paper provides the first regression discontinuity design analysis of the impact of concealed weapons bans on crime. Following a ban on carrying of concealed weapons in Brazil, gun-related homicides fell by 3,900 (10.8 percent of the total number of such homicides in the country) in the year following the regulation, the analysis shows. The paper shows that young black males living in high-crime areas disproportionately benefitted from the regulation – both because the drop in gun-related homicides was particularly pronounced among that population, and because in the wake of the law young black men were more likely to enroll in public adult education. The research here also shows that non-gun-related homicides were not affected by the regulation, and that the number of gunshots intended to kill decreased after the law, but accidental gunshots were not affected.

The economic value of the regulation I study can be estimated using the literature on the value of a statistical life. In Brazil, estimations of the value of statistical life vary from $0.77 million to $6.1 million (Ortiz, Markandya and Hunt, 2009). Therefore, using the most conservative value and my estimation for the reduction in gun-related homicides caused by the regulation, I can make the following claim: The prohibition of the right to carry concealed weapons generated an economic value of $3 billion in one year. This number is about six times the value of the Australian gun buyback (Leigh and Neil, 2010). Although, the decrease in the number of gun-related deaths per year attributed to the gun buyback in Australia was much smaller and different in nature (200 and mostly suicides) than the decrease estimated in this work (3,900 and mostly gun-related homicides), the value of statistical life in Australia is close to $2.5 million, i.e., 3.2 times larger than the amount I use to generate my estimation for Brazil. My calculation, therefore, could be

understated because I considered only the most conservative value of statistical life. Additionally, as I showed in my analysis, gunshot wounds intended to kill were reduced by 12.3 percent. The total health spending in gunshot wounds intended to kill in 2003 was 13.2 million Brazilian Reais (equivalent to $4.6 million at that time). Therefore, the law generated an additional economic value of $565.8 thousand through this channel.[51]

I also show that the legislation decreased illegal gun carrying, robbery and total arrests. However, reported rapes, thefts and drug-trafficking incidents were not affected. Lastly, this work establishes a link between the legislation that prohibited the carrying of concealed weapons that came passed into law in December 2003, and a voter referendum to prohibit the sale of all weapons and ammunition that took place in October 2005. My results show that areas that experienced larger decreases in gun-related homicides also experienced higher levels of voter turnout and showed greater levels of support for the referendum that proposed a complete firearms ban.

The places that experienced larger decreases in gun-related violence following the enactment of the concealed carry ban were largely concentrated in regions that represent about 39 percent of the Brazilian population (i.e., places with above-median levels of vulnerability as measured by a vulnerability index). By comparison, 36 percent of voters cast ballots in favor of the gun ban. These findings underscore potential problems for direct democracy (i.e. referendums and initiatives put directly to voters rather than legislation passed by elected representatives); when the benefits of decreasing negative externalities, in this case gun-related externalities, are concentrated in a share of the population representing less than 50 percent of the voting public, these benefits might be ignored by the majority of voters. If these externalities are large enough,

[51] This calculation is underestimated as it does not consider the days of work missed by the gunshot wounds' victims while they were hospitalized and during their post-hospital recovery, nor it does consider the rehabilitation costs (such as medical drugs).

ignoring them will result in an outcome with a lower social welfare. Therefore, in these situations, referendums should not be used (Maskin and Tirole, 2004).

My results could be even larger in a context such as those with easier border controls and more effective policing and easier border controls. Leigh and Neil (2010) conclude their work by saying that extrapolating their results to other countries is not trivial. First, Australia does not have land borders, making it easier to control illegal firearm imports, and secondly, its government and policing services are highly organized and effective. Brazil, on the other hand, does not have these advantages. Therefore, prohibiting gun carrying in a country with easier border controls and more effective policing could provide a larger decrease in gun-related homicides.

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Table 1 – Descriptive statistics of crime in Brazil and the state of São Paulo in 2003

Crime	Total
Homicides - Brazil	
Gun related homicides	36,115
Non-Gun related homicides	14,928
Other Crimes – São Paulo	
Robbery	332,229
Theft	645,529
Rape	3,978
Drug Trafficking	13,935
Illegal Gun Carrying	17,253

Table 2 – RDD estimating the concealed carry prohibition effect on Gun and Non-Gun related homicides

VARIABLES	(1) Total Homicides	(2) Non-gun Related Homicides	(3) Gun Related Homicides
Concealed Carry Prohibition 12 months bandwidth	-0.227*** (0.070)	-0.036 (0.046)	-0.191*** (0.053)
Concealed Carry Prohibition 24 months bandwidth	-0.108*** (0.029)	0.003 (0.018)	-0.111*** (0.022)
Concealed Carry Prohibition 48 months bandwidth	-0.127*** (0.021)	-0.009 (0.013)	-0.119*** (0.016)

Robust standard errors clustered at the municipality level are in parenthesis. Each line shows different bandwidth selection. First row regressions contain 71,420 observations. Second row regressions contain 139,925 observations. Third row regressions contain 277,129 observations. All regressions control for calendar months, rain and temperatures All municipalities with more than 10,000 people are considered. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3 – Falsification test

Cutoff	(1) Gun-related homicides	(2) Observations
Concealed Carry Prohibition Cutoff – January 2004	-0.191*** (0.053)	71,420
Concealed Carry Prohibition Cutoff – January 2003	0.059 (0.050)	71,224
Concealed Carry Prohibition Cutoff – January 2002	0.059 (0.049)	71,049
Concealed Carry Prohibition Cutoff – January 2001	-0.048 (0.050)	70,260
Concealed Carry Prohibition Cutoff – January 2000	0.084* (0.045)	69,475
Concealed Carry Prohibition Cutoff – January 1999	0.048 (0.050)	69,379
Concealed Carry Prohibition Cutoff – January 1998	-0.073 (0.049)	69,446
Concealed Carry Prohibition Cutoff – January 1997	0.031 (0.049)	69,268

Robust standard errors clustered at the municipality level are in parenthesis. Bandwidth is equal to 12 months. All regressions control for calendar months, rain and temperatures All municipalities with more than 10,000 people are considered. *** p<0.01, ** p<0.05, * p<0.1

Table 4 – Descriptive statistics

Race	Gun-related homicides	Age	Gun-related homicides
White	13,224	Less than 15	495
Black	20,291	Between 15 and 29	21,371
Other	2,600	More than 29	14,249
Total	36,115	Total	36,115

Note: The descriptive statistics correspond to the year of 2003. Race is divided in three groups: white, black (composed by black and a race denominated “pardo” in Brazil, commonly translated by mulatto), and other (composed by yellow, Indians and not-identified). Locality is divided in five groups: out of home (composed by places where people drive on and places where people go to walk, work, study, shop, practice sport, enjoy leisure and so on), detention center (composed by prison, youth detention center, orphanage, hospice, nursing home), residence (gun-related homicides inside the residence), farm (gun-related homicides inside the farm), and non-identified.

Table 5 – Gun-related homicides by race and age

Panel A - race

VARIABLES	(1) Gun Related Homicides White	(2) Gun Related Homicides Black	(3) Gun Related Homicides Other
Concealed Carry Prohibition	-0.007	-0.153***	-0.029*
	(0.029)	(0.037)	(0.016)
Observations	71,420	71,420	71,420

Panel B - age

VARIABLES	(1) Gun Related Homicides 15 – 29 years' old	(2) Gun Related Homicides More than 29 years' old	(3) Gun Related Homicides Less than 15 years' old
Concealed Carry Prohibition	-0.112***	-0.075**	-0.003
	(0. 035)	(0.034)	(0.006)
Observations	71,420	71,420	71,420

Robust standard errors clustered at the municipality level are in parenthesis. Bandwidth is equal to 12 months. All regression control for calendar months, rain and temperatures. All municipalities with more than 10,000 people are considered. *** p<0.01, ** p<0.05, * p<0.1

Table 6 – Quartile analysis

VARIABLES	(1) < 25%	(2) >25% and <50%	(3) >50% and <75%	(4) >75%
Concealed Carry Prohibition	-0.064 (0.057)	-0.044 (0.072)	-0.085 (0.102)	-0.499*** (0.154)
Observations	17,769	17,950	17,951	17,750

Robust standard errors clustered at the municipality level are in parenthesis. Column 1 splits off the lowest 25% municipalities according to gun-related homicide rates. Column 2 splits off municipalities with gun-related homicide rates larger than the lowest 25%, but smaller than the highest 50%. Column 3 splits off municipalities with gun-related homicide rates larger than the lowest 50%, but smaller than the highest 75%. Column 4 splits off the highest 75% municipalities according to gun-related homicide rates. This analysis considers only municipalities with more than 10,000 people. Bandwidth is equal to 12 months. All regressions control for calendar months, rain and temperatures. *** p<0.01, ** p<0.05, * p<0.1

Table 7 – Gunshot wounds by intention

VARIABLES	(1) Gunshot wounds intended to kill	(2) Accidental gunshot wounds	(3) Total gunshot wounds
Concealed Carry Prohibition	-0.109***	-0.030	-0.114**
	(0.038)	(0.035)	(0.055)
Observations	13,738	13,738	13,738

Robust standard errors clustered at the municipality level are in parenthesis. Bandwidth is equal to 12 months. All regression control for calendar months, rain and temperatures All municipalities with more than 50,000 people are considered. *** p<0.01, ** p<0.05, * p<0.1

Table 8 – Socioeconomic variables used to construct the vulnerability index

i	Variables[52]	Obs.	Mean	Std. Dev.	Min	Max
1	% of moms (15-17 years)	5507	8.5	6.5	0	57.9
2	% of people (15-17 years) that have never been to school	5507	2.1	3	0	34.3
3	% of people (15-19 years)	5507	10.7	1.3	4.4	16
4	Male homicides per 100.000 pop. (15-29 years)	5507	29	40	0	431
5	% of population growth (1997 to 2001)	5507	6.1	13.6	-50.2	171.6
6	Monthly household per capita income (in Brazilian Reais)	5507	170.8	96.4	28.3	954.6

[52] Variables 1 to 3 and variable 6 are collected from the 2000 Census obtained at IBGE (Brazilian Institute of Geography and Statistics). The remaining variables are obtained at IPEADATA (Institute of Applied Economic Research). Variable 4 calculates the average between 1996 and 2005 as this variable oscillates substantially across years.

Table 9 – Relationship between the concealed carry prohibition and the vulnerability index

VARIABLES	(1) Gun Related Homicides
Concealed Carry Prohibition*Vulnerability Index	-0.011*** (0.003)
Observations	71,420

Robust standard errors clustered at the municipality level are in parenthesis. Bandwidth is equal to 12 months. All regression control for calendar months, rain and temperatures All municipalities with more than 10,000 people are considered. *** p<0.01, ** p<0.05, * p<0.1

Table 10 – DID analysis showing the effect of concealed carry prohibition on gun-related homicides

VARIABLES	(1) Gun Related Homicides
Post*Vulnerability Index	-0.146*** (0.039)
Observations	5,757

The regression is controlled by municipal fixed effects. Robust standard errors are in parenthesis. The regression is additionally controlled by population and income. All municipalities with more than 10,000 people are considered. *** p<0.01, ** p<0.05, * p<0.1

Table 11 – DID analysis showing the effect of concealed carry prohibition on school enrolment

VARIABLES	(1) School enrollment men	(2) School enrollment women
Post*Vulnerability Index	6.494***	3.036
	(2.066)	(2.241)
Observations	5,770	5,770

The regression is controlled by municipal fixed effects. Robust standard errors are in parenthesis. The regression is additionally controlled by population and income. The year dummy assumes the value of one when year equals to 2005 and zero when year equals to 2004. All municipalities with more than 10,000 people are considered. *** p<0.01, ** p<0.05, * p<0.1

Table 12- OLS regression using vote in favor of gun prohibition as the dependent variable

VARIABLES	(1) Vote in favor of the prohibition Brazil	(2) Vote in favor of the prohibition Brazil	(3) Vote in favor of the prohibition São Paulo state
Vulnerability index	0.227***	0.262***	0.204***
	(0.046)	(0.044)	(0.068)
Socio-economic controls	No	Yes	Yes
Proxy for number of guns	No	No	Yes
State fixed effects	Yes	Yes	No
Microregion fixed effects	No	No	Yes
São Paulo state only	No	No	Yes
Observations	5,507	5,505	645
R-squared	0.650	0.682	0.532

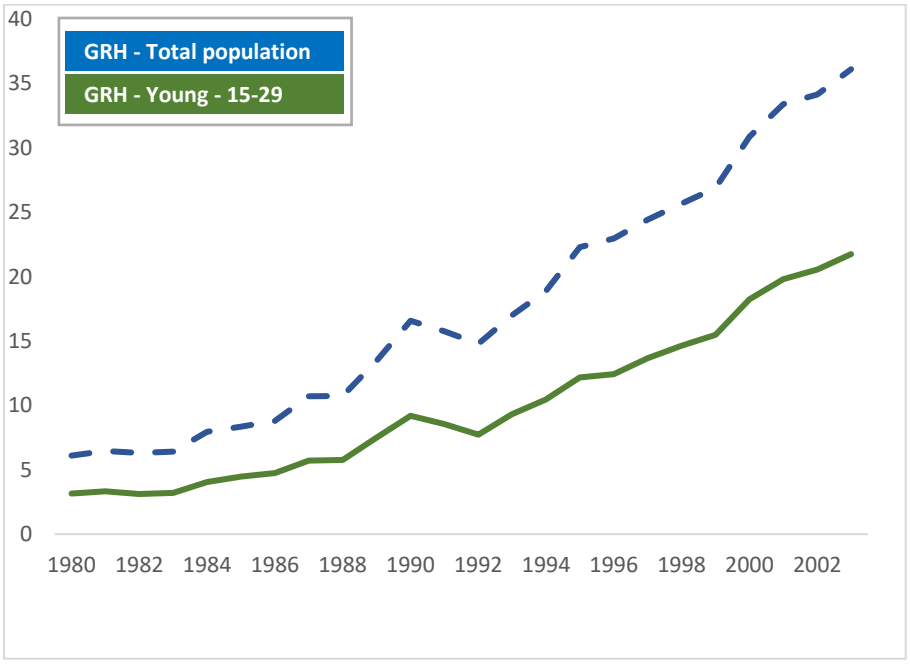
Robust standard errors clustered at the microregion (557 total) level are in parenthesis. The socio-economic controls contain population, percentage of people living in rural areas, per capita GDP, ideology, distance to state capital, per capita conditional cash transfer, women to men ratio, per capita number of cattle, dummy for drought, dummy for land reform protest, percentage of land bought by the government and redistributed to landless farmers. The proxies for number of guns are defines as the number of illegal gun carrying and illegal gun firing. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 13- OLS regression using voting turnout in the referendum as the dependent variable

VARIABLES	(1) Voting Turnout
Voting Turnout in 2004	0.322***
	(0.090)
Vulnerability index	-0.014***
	(0.002)
Voting Turnout in 2004 * Vulnerability index	0.013***
	(0.003)
Observations	5,502
R-squared	0.729

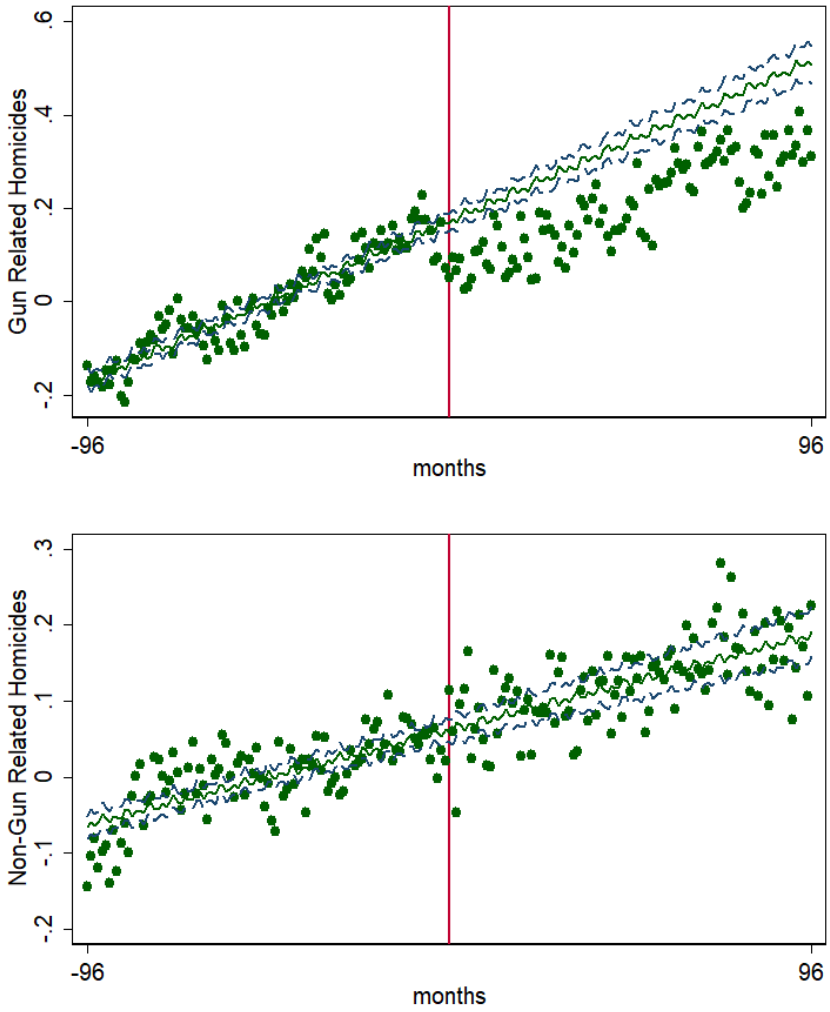
Robust standard errors clustered at the microregion (557 total) level are in parenthesis. The regression is additionally controlled by population and per capita GDP. *** p<0.01, ** p<0.05, * p<0.1

Figure 1 – Yearly gun-related homicides (GRH) in the Brazilian territory (in thousand).



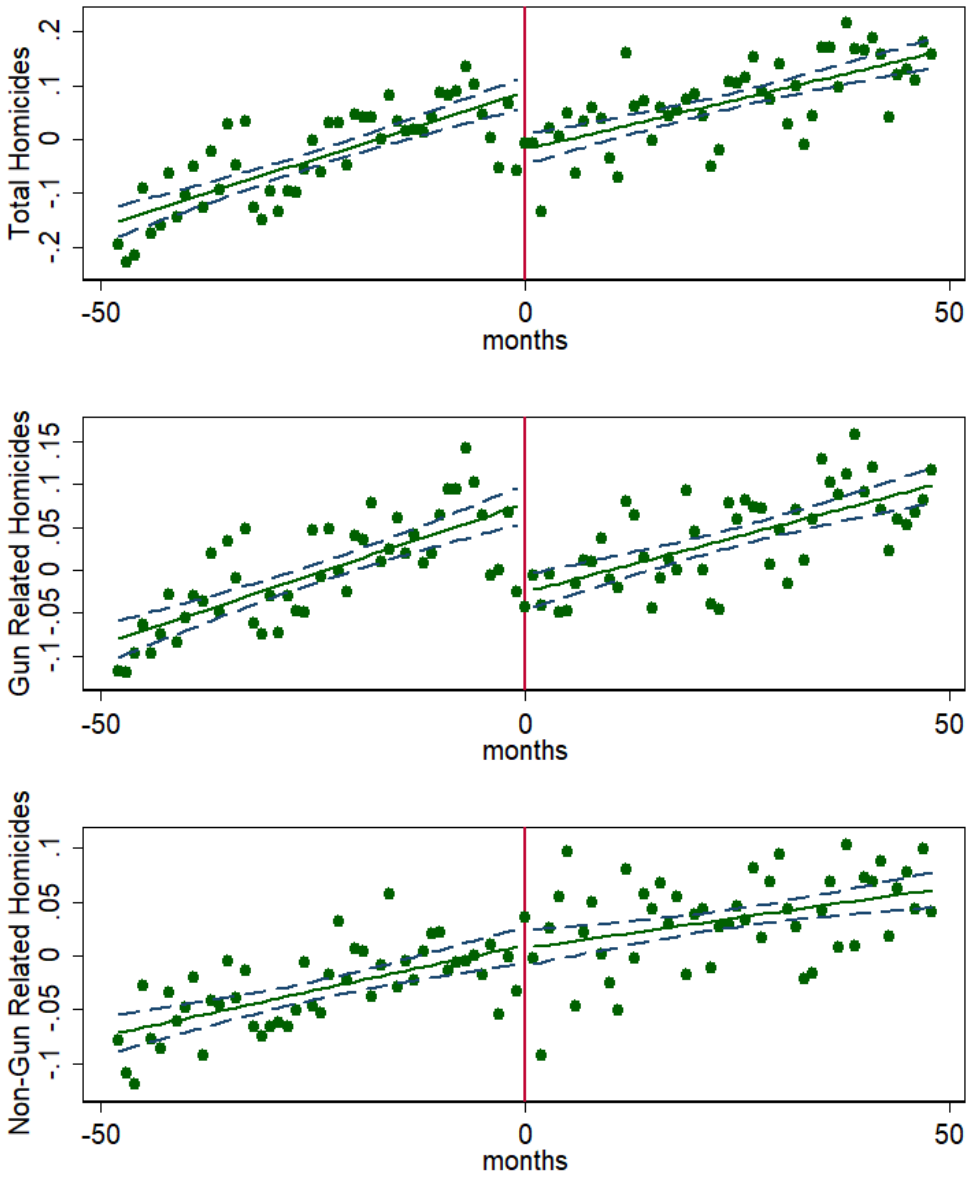
Notes: The data is available at DATASUS. The dashed line shows the total gun-related homicides, and the solid line shows the gun-related homicides concentrated on 15-29 years old people (close to 60% of the total gun-related homicides).

Figure 2 – Gun-related and non-gun related homicides trends



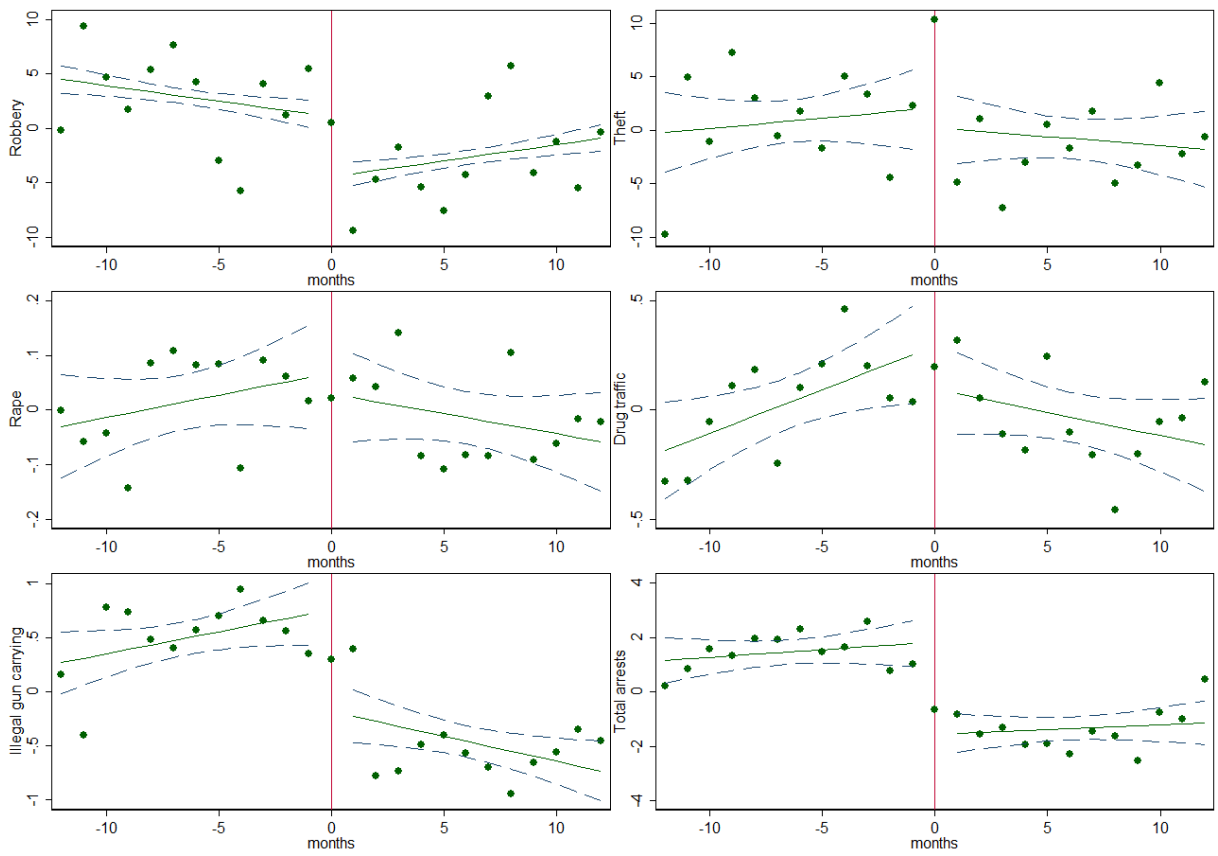
Notes: The top graph shows scatter plots representing the monthly gun-related homicides per 100,000 people and the bottom graph shows scatter plots representing the monthly non-gun related homicides per 100,000. The vertical line at month zero represents the intervention. The solid function is fitted using an OLS regression and the dashed line represents the 95% confidence interval. The part of the function after the intervention contains predicted values using the pre-intervention data. I first regress the dependent variables on calendar months to take seasonality into account. Then, I regress the predicted residuals on time and pairs of cosine and sine functions.

Figure 3 – Effect of the concealed carry prohibition on total homicides, gun-related homicides and non-gun-related homicides per 100,000 people



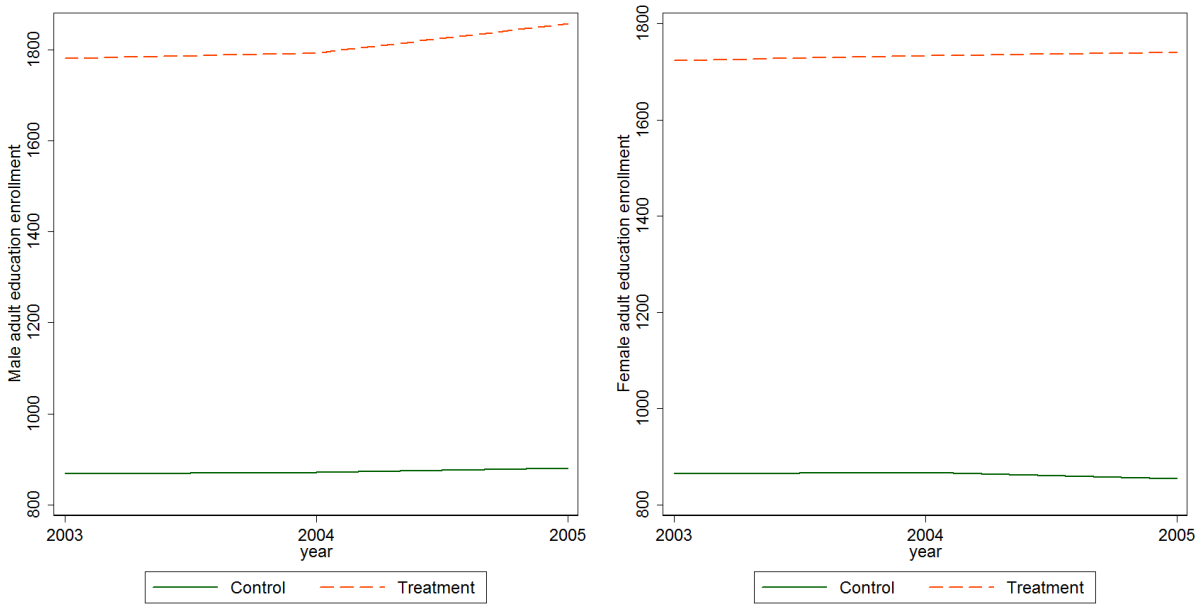
Notes: Figure 3 shows three time-varying functions using a 48 months' bandwidth and a vertical red line representing the cutoff point (January 2004). The solid line is fitted separately on each side of the threshold, and the dashed line represents the 95% confidence interval. The scatter plots show monthly averages. I regress the predicted residuals after regressing my dependent variables on calendar months, monthly rainfall and temperatures to take seasonality into account.

Figure 4 – Concealed prohibition effect on gun-related homicides (GRH), non-gun-related homicides (NGRH), total homicides and other crimes



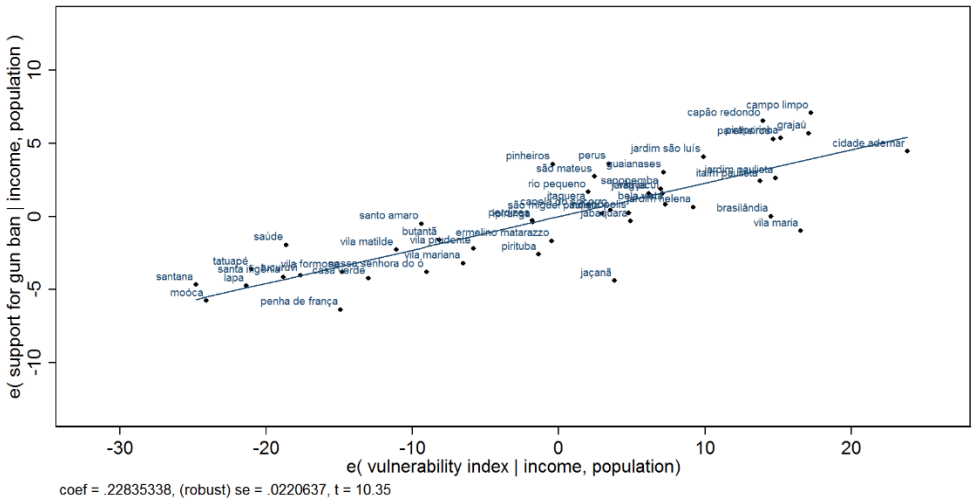
Notes: Figure 4 shows, for each crime, two time-varying function using a 12 months' bandwidth and a vertical red line representing the cutoff point (January 2004). The solid line is fitted separately on each side of the threshold, and the dashed line represents the 95% confidence interval. The scatter plots show monthly averages. I regress the predicted residuals after regressing my dependent variables on calendar months, monthly rainfall and temperatures.

Figure 5 – Average enrollment in adult education per 100,000 inhabitants



Notes: The dashed line represents the municipalities with above median vulnerability index. The solid line represents the municipalities with below median vulnerability index. All municipalities with more than 10,000 people are considered.

Figure 6 – Relationship between voting for the prohibition and vulnerability index



Notes: The dashed line represents the least square estimation of the relationship between the *residuals* of the linear regression of support for gun control on population and income and the *residuals* of the linear regression of the vulnerability index on population and income. The regression considers all 47 neighborhoods of the São Paulo municipality for which the TSE provides information on.

Appendix

A1, F1 – Model specifications and restricting the bandwidth

I first show that the concealed carry prohibition effects on gun-related homicides are not sensitive to varying the model, presented on Table 2, specifications. Table A1 shows that adding fixed effects or Fourier terms do not substantially change the results. When I use a Poisson regression I find that gun-related homicides were reduced by 8.5%.[53] Finally, restricting the sample to municipalities with more than 50,000 and 100,000 people slightly change the concealed carry prohibition impact on gun-related homicides. In the former case, concealed carry prohibition reduces gun-related homicides by 4,073 in 2004 and in the latter, it reduces gun-related homicides by 4,516 in 2004. Both numbers are close to the original estimation of 3,900.

A2 – Using a survey data as robustness check

To increase confidence in my results showing that exposure to gun violence explain vote in the referendum, I use a public opinion survey asking voters whether they would vote in favor of or against the gun prohibition. This survey took place two days before the referendum. The questionnaire also asked voters if they, themselves, were subjected to gun violence or if they had a family member or close friend who sustained a gun injury. The remaining survey questions relevant for this paper asked voters whether they had guns in their homes, if they were robbed at least once, if they would vote even if it was not mandatory to vote, and if they ever considered buying a gun to protect themselves. I also take race into account as blacks were disproportionately

[53] As the coefficient of interest is a dummy variable, the interpretation of the Poisson estimation is intuitive. The percentage change in gun-related homicides is equal to $e^{\widehat{\beta}}$-1. The 8.5% reduction in gun-related homicides is close to the reduction estimated using the original model (10.8%). This result is not sensitive to municipalities' threshold selection. For instance, when I restrict my sample to municipalities with more than 50 and 100 thousand inhabitants, I find respectively that gun-related homicides were reduced by 7.3% and 7.5% (all significant at the 0.01 level).

affected by the concealed carry prohibition. As the dependent variable is binary, I use a logistic regression to assess whether groups more likely to be benefitted by the concealed weapon ban (i.e. people more exposed to gun violence), voted more in favor of the gun prohibition.

Table A2 shows how personally being exposed to gun injury or having a close relationship with someone exposed to gun violence is an important predictor of casting a vote in favor of the prohibition. In accordance to the argument defended in this paper, people exposed to gun violence were 1.48 times more likely to vote in favor of the prohibition.[54] Additionally, income, gun ownership, and ever considering buying a gun was negatively related to voting in favor of the gun ban. Blacks were more likely to support the gun prohibition and the variable "would vote" showed that those willing to vote in the referendum, even if vote was not mandatory, were 1.76 times more likely to support the gun ban. This shows that people supporting the gun prohibition were more willing to politically participate in the referendum.

A3, A4 – Does timing matter?

This subsection investigates whether having an increase in gun-related homicides close to the election is important in explaining the vote for the gun ban. Angatuba, a small town (20,000 inhabitants) in the countryside of the state of São Paulo serves as an anecdotal evidence. Angatuba showed the largest support for gun ban in the São Paulo state, and one way to explain this support is through the gun related homicide that happened in this municipality one month before the referendum took place. This is especially relevant in this case because Angatuba did not have gun related homicides since August 2002. To test this argument for the whole country, I propose a

[54] 1.48 represents the ratio of the odds for being exposed to gun violence to the ratio of the odds for not being exposed, which is calculated by exponentiating the coefficient for being exposed to gun violence (0.393).

variable that measures gun related homicides' deviation from the historical average.[55] This variable is constructed to measure the impact of an increase in gun related homicides, within one year of the referendum, on its outcome. Table A3 presents the estimated coefficient and shows that one deviation from the mean increases the support for gun prohibition by .62 percentage points Table A4 shows that this effect vanishes as the gun related homicides' deviation from the historical average happens further from the referendum, which I test by simulating different months in which the referendum took place (in which October 2005 is the correct month).

[55] Formally, this variable is constructed as follows: $Std.Death_i = \frac{(\sum_{m=1}^{12} deaths_{mi}) - Yearly\ Historical\ Average_i}{Standard\ Deviation_i}$, where $deaths_{mi}$ indicates the number of gun related deaths at municipality i, on month m. More specifically, $deaths_{12i}$ represents the number of gun related deaths, at municipality i, on the month in which the referendum happened (12). The Yearly Historical Average and standard deviation takes into account the period between 1996 and 2005. The monthly data on gun related death was collected at DATASUS.

Table A1 – RDD estimating the ED effect on total homicides and Gun and Non-Gun related homicides

VARIABLES	(1) Total Homicides	(2) Non-gun Related Homicides	(3) Gun Related Homicides
ED - original	-0.227***	-0.036	-0.191***
	(0.070)	(0.046)	(0.053)
ED - fixed effects	-0.162**	-0.011	-0.151***
	(0.071)	(0.047)	(0.053)
ED - sine, cosine	-0.235**	-0.032	-0.202***
	(0.093)	(0.060)	(0.070)
ED - Poisson	-0.046**	0.055	-0.089***
	(0.023)	(0.042)	(0.027)
ED - 50,000	-0.372***	-0.073	-0.298***
	(0.103)	(0.056)	(0.084)
ED - 100,000	-0.439***	-0.031	-0.408***
	(0.127)	(0.067)	(0.105)

Robust standard errors clustered at the municipality level are in parenthesis. Bandwidth is equal to 12 months. All regression control for calendar months, rain and temperatures. Rows 1 – 3 consider municipalities with more than 10,000 people and contains 71,420 observations. Row 1 uses the original estimation presented on Table 1. Row 2 adds fixed effects. Row 3 adds sine and cosine functions and their interaction. Row 4 uses the Poisson regression model with municipality fixed effects and uses homicides counts instead of homicides rates as dependent variable. This model drops municipalities that contains all zero outcomes, therefore, the number of observations for columns 1, 2 and 3 are respectively 63,406; 56,558 and 54,131. Row 5 and 6 use the original estimation, but restrict the sample to municipalities with respectively more than 50,000 and 100,000 people. Row 5 and 6 contain respectively 13,738 and 6,059 observations. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table A2 – Logistic regression showing the relationship between exposure to gun injury and voting in favor of the prohibition

VARIABLES	Vote in favor of the prohibition
Monthly household income	-0.103***
	(0.039)
Blacks	0.299***
	(0.100)
Have gun	-1.287***
	(0.215)
Injured by a gun	0.393***
	(0.106)
Age	0.003
	(0.003)
Men	-0.044
	(0.101)
Would vote	0.569***
	(0.097)
Considered buying a gun for protection	-0.952***
	(0.127)
Robbed	-0.094
	(0.116)
Observations	1,925

Robust standard errors (in parenthesis). *** p<0.01, ** p<0.05, * p<0.1

Table A3- OLS regression showing the relationship between voting in favor of gun prohibition (dependent variable) and gun-related homicides' deviation from the historical average

VARIABLES	Vote in favor of the prohibition
gun-related homicides std.	0.622**
	(0.262)
Observations	5,505
Number of Microregion	557

The regression use microregion fixed effects and robust standard errors are adjusted for clusters at the microregion level. It is additionally controlled for women to men ratio, CCT spending per capita, ideology distance to capital, income per capita, number of cattle per rural worker, population, rural population, vulnerability index, drought, land protest, public distribution of agricultural land. *** p<0.01, ** p<0.05, * p<0.1

Table A4 – OLS regression simulating different dates in which the referendum took place

VARIABLES	(1) Oct. 2005	(2) Sep. 2005	(3) Aug. 2005	(4) Jul. 2005	(5) Jun. 2005	(6) May. 2005	(7) Apr. 2005	(8) Mar. 2005	(9) Feb. 2005	(10) Jan. 2005
gun-related homicides std.	0.622**	0.604**	0.514*	0.438	0.467*	0.310	0.346	0.072	0.089	0.181
	(0.263)	(0.276)	(0.284)	(0.289)	(0.271)	(0.276)	(0.269)	(0.267)	(0.277)	(0.280)
Observations	5,505	5,505	5,505	5,505	5,505	5,505	5,505	5,505	5,505	5,505
Number of Microregion	557	557	557	557	557	557	557	557	557	557

The regressions use microregion fixed effects and robust standard errors are adjusted for clusters at the microregion level. It is additionally controlled for women to men ratio, conditional cash transfer spending per capita, ideology distance to capital, income per capita, number of cattle per rural worker, population, rural population, vulnerability index, drought, land protest, public distribution of agricultural land. *** p<0.01, ** p<0.05, * p<0.1