

Law incentives for juvenile recruiting by drug trafficking gangs: empirical evidence from Rio de Janeiro

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Abstract. We evaluate the deterrence effects of the age of criminal responsibility on total drug trafficking and homicide crimes per age, based on a quasi-experiment generated by differences in punishment severity for these crimes prescribed by the Statute of the Child and Adolescent and by the Penal Code in Brazil. To this end, information from arrests conducted by the civil and military police of Rio de Janeiro in 2016 and 2017 is used to estimate the local effects of treatment through a Regression Discontinuity Design. Instead of using recidivism data and/or grouping crimes with distinct punishment severity, we use as an outcome variable the total number of arrests (crimes) per age for drug trafficking and homicides, which are the most common crimes related to organized crime in Rio de Janeiro. The results indicate that, *ceteris paribus*, the increase in punishment severity generated by the Penal Code can reduce the number of drug trafficking-related crimes by 9% and homicides by 37%. Through simple cost-benefit analysis, we suggest that increasing the punishment severity for minors who commit homicide could reduce juveniles' engagement in a criminal career associated with gangs and generate gains in social well-being.

Keywords: Deterrence; Punishment Severity; Drug Trafficking Gangs; Rio de Janeiro

1. INTRODUCTION

Brazil is one of the most violent countries in the world, and much of the violent criminality can be linked to organized crime groups' guns and drug trafficking operations (Carvalho and Soares 2016). This link is very prominent in the Brazilian state of Rio de Janeiro,³ where the illicit retail drug market is dominated almost exclusively by three criminal organizations: *Comando Vermelho*, *Terceiro Comando*, and *Amigos dos Amigos*.

Such drug trafficking gangs, formed within the Brazilian penitentiary system, recruit gang members who gradually perform more essential roles in their careers. They start as lookouts or local transporters. After that, they can become sellers or soldiers, and, at the top of their careers, they can be appointed managers. Drug trafficking gang members earn on a commission basis or are paid a monthly or weekly salary according to their role in the organization to progress on a criminal career path. Their recruitment process starts at an early age, and many are juveniles (Silva and Urani 2002; Dowdney 2003; Carvalho and Soares 2016).⁴

Gang association comes with a price, and young gang members suffer a great deal from the violence involved in drug trafficking activities. Carvalho and Soares (2016) reported that 20% of their sample, composed of members of drug-trafficking gangs in the *favelas* of Rio de Janeiro, had been murdered two years after the first interview. A similar situation can be observed in other cities in the country. Nearly four in every 1,000 Brazilian adolescents living in the country's biggest cities are murdered before the age of 19, making Brazil not only the country with the highest homicide rate but also one of the countries with the highest levels of lethal violence against children and adolescents (Waiselfisz 2017).

Juveniles are recruited by organized crime in many other places worldwide (Comunale *et al.* 2020). Numerous studies have sought to understand the causes of youth engagement in such organizations. Literature on juveniles' recruitment for criminal activities has focused on three potential explanations: social, psychological, and economic. Ostrosky *et al.* (2012) argue that juveniles are attracted by lifestyles dominated by the cult of violence and the experience of owning material goods. The likelihood of being recruited at younger ages is also positively associated with problems at school, drug use, low socio-economic conditions, and a lack of prospects (Silva and Urani 2002; Arsovska 2015; Carvalho and Soares 2016). In this regard, growing up in a poor neighborhood in a socio-economically deprived environment facilitates recruitment into drug trafficking gangs (Carvalho and Soares 2016; Decker and Chapman 2008; Sergi 2016; Van San and Sikkens 2017). Other studies show that family ties are facilitators to access criminal careers since family members and close friends are easier to trust in the criminal environment where there are no third parties to regulate disputes (Arsovska 2015; Salinas *et al.* 2011; Sergi 2016; Van Koppen 2013). Substance abuse, childhood conduct disorder, and some psychopathological traits, such as a lack of empathy and cruelty, have increased juveniles' likelihood of involvement in criminal activities. Such profiles are compatible with risky and violent activities like the drug trafficking business (Ostrosky *et al.* 2012). Relatedly,

³ Note that the problem of violence and criminality is widely spread in Brazil. Cerqueira *et al.* (2021) and other documents from the Brazilian Public Security Forum (FBSP) also point out the Amazon and the Northeast regions as very important geographic regions for crime in Brazil.

⁴ Carvalho and Soares (2016) estimated that 6.5% of men aged 10 to 25 living in the *favelas* were members of drug trafficking gangs in Rio de Janeiro (the capital of the state with the same name).

anthropologists such as Alba Zaluar (see Zaluar, 2010) or Nancy Scheper-Hughes (see Scheper-Hughes, 2004) have pointed out the role of structural violence⁵ present in Brazilian society as a critical factor in understanding the enrollment of endangered adolescents (exposed to such structural violence) in gang-related criminal activities. A recent study from Maschietto et al. (2022), centered on the views of youth individuals, shows that nowadays, youngsters still point out, as an important factor to overcome the structural violence they face, the need to change values through (peace) education and to fight social stigmas such as chauvinism or racism.

In this article, we examine a further factor that could explain the recruitment of juveniles by criminal organizations and the environment of violence, reaching the age of penal majority. We argue that the lenient Brazilian Penal Code encourages the recruitment of juveniles by drug trafficking gangs. We hypothesize that, *ceteris paribus*, drug trafficking-related crimes committed by juveniles are significantly reduced when they reach the age of majority and face more severe punishments. We use a quasi-experiment generated by the age of criminal responsibility to evaluate the impacts of punishment severity on crimes in the vicinity of adulthood.

To achieve this, we gathered detailed information on all arrests made in 2016 and the first half of 2017 in the Brazilian state of Rio de Janeiro. We address two critical issues when we process this crime data: aggregation bias and the possible existence of incapacitation effects. First, instead of using aggregated crime types (including crimes with different severity of punishment), we focus on two crimes primarily related to Rio de Janeiro's criminal organizations: drug trafficking and homicides. Importantly for us, both types of crime have predicted and real differences regarding punishment severity for minors and those over 18 years of age in Brazil.⁶

Second, instead of focusing on recidivism,⁷ we evaluate the deterrence effects of differences in the severity of punishment on the total number of crimes per age. This way, we avoid the censoring problem in the observed sample of offenders. This problem arises when recidivism is used as an outcome variable since many individuals do not re-offend due to the incapacitation effects of applied punishments.⁸ Therefore, we adopt three strategies that produce very robust results. First, we consider each crime an independent occurrence (independent of who perpetrated it) to compute the total number of crimes per age. Second, we consider each crime an independent event for minors while we consider only the first appearance in the adult dataset. This option is selected because, at 18 years of age, all Brazilians are considered first-time defendants, so all previous criminal records as minors are erased. Hence, all individuals start adulthood with no prior records. If they are arrested for an offense, it can be considered the

⁵ Scheper-Hughes (2004) defines structural violence as the invisible "social machinery" of social inequality and oppression that reproduces pathogenic social relations of exclusion and marginalization via ideologies and stigmas attendant on race, class, caste, sex, and other invidious distinctions.

⁶ In the appendix, we show as a placebo exercise that for crimes such as thefts, assaults, and threats, for which differences in punishment severity are not as great or are inexistent, there are no statistically significant differences in total crimes per age in the vicinity of 18 years old.

⁷ If recidivism is used as an outcome variable, individuals will be excluded from the sample because they are serving a sentence or waiting for a prison sentence (see Arora 2019; Loeffler and Grunwald 2015).

⁸ For the case of youngsters (17–19) arrested for homicides (including attempts to commit homicide and homicide), 37% of our sample were repeat offenders. Note that this re-offending percentage comes mostly from attempts to commit homicide at 42%, compared to 14% of those that committed homicide. In the case of drug trafficking crimes, the average re-offending probability was 27% for individuals aged 17–19.

“first crime” of adult life.⁹ Finally, we only consider arrest data for individuals when they appear for the first time in our data set. The results are robust and very consistent for the three options to compute our outcome variable.

The early stages of criminal law's deterrence effects are essential to evaluate because many authors, such as Bell *et al.* (2018), have highlighted the significance of the first crime in determining criminal careers. These authors argued that earlier experiences of crime could increase juveniles' stock of criminal knowledge and potentially reduce the costs of subsequent crime participation. In addition, a first criminal record can reduce the adult's expected wage in the legal labor market. Both effects would increase an individual's likelihood of becoming a career criminal. Once they start a criminal career, the chances of leaving it are minimal.

Our main results show that, *ceteris paribus*, the increase in punishment severity generated by the Brazilian Penal Code can reduce the number of drug trafficking crimes and homicides committed by youngsters by 9% and 37%, respectively. Therefore, as long as these crime types can be attributed to gang activity, harsher punishment can inhibit recruitment and, consequently, the participation of juveniles in jobs related to drug trafficking gangs, such as dealers and soldiers.

The remainder of this article is organized into five sections. Section 2 reviews the theoretical and empirical literature about the deterrence effects of punishment severity. Section 3 presents the institutional background that significantly changes punishment severity for Brazil's drug trafficking and homicide crimes. Section 4 describes the database and the methodology used. Section 5 presents the results, and Section 6 presents the main conclusions of this study.

2. DETERRENCE EFFECTS OF PUNISHMENT SEVERITY: A LITERATURE REVIEW

The seminal work of Becker (1968) presented a simple decision-making model in which potential criminals respond rationally and consistently to incentives. In this model, crime arises in a decision-making process by rational agents who maximize the expected utility of crime. On the one hand, they consider crime's psychological and monetary benefits. On the other hand, they consider its costs, measured by the likelihood of some punishment and by the monetary equivalent of the severity of the punishment. Given that the agents have no income restrictions in the model, any combination of punishment probability and severity greater than the benefits of the crimes would deter potential offenders. Considering this reasoning, the author concluded that more severe punishments would be more efficient because, in general, they have lower costs than the expenditure needed to increase the likelihood of punishment. Among other things, this effect would justify the adoption of maximum penalties.¹⁰

⁹ By restricting the data set to the first crime as adults, we also abstract from incentives to re-offend as adults that could vary due to the Penal Code.

¹⁰ In the same vein, Polinsky and Shavell (1984) showed that punishment in fines is more efficient than imprisonment because the public costs of applying this type of punishment are low. Thus, following Becker (1968), the maximum pecuniary fine (the total income of the offender) would be optimal. However, the authors draw attention to the fact that this fine could be less than the loss caused by the criminal. Therefore, some combination with a period of incarceration would be optimal as long as the marginal cost of incarceration is not too high. Thus, in theoretical models, incarceration occurs as a complement to pecuniary fines and as an alternative to changes in the likelihood of punishment. Of course, this analysis disregards the fact that incarceration can also reduce crimes due to the effects of incapacitation.

Regarding deterrence, there is no consensus that combining low punishment probability with more severe punishments is the best combination to deter potential criminals. For example, contrary to what Becker (1968) suggested, Andreoni (1991) argued that the severity of the punishment must be proportional to the crime. The author claimed that the sentence's severity and likelihood are not entirely independent because judges tend to apply more severe penalties less often. This distinction occurs because judges tend to apply the punishment only when they are sure of the defendant's guilt in the face of more severe sentences. Furthermore, Garoupa (1998) argued that harsh punishments associated with low punishment probability only work under specific conditions. They fail when there are social costs in punishing or imperfect information regarding punishment probability.¹¹

Faced with this lack of consensus on the most efficient combination to deter crime, a natural path is an evaluation through empirical evidence. However, these effects are not easy to separate empirically because whenever the severity of the punishment changes, as Andreoni (1991) proposed, there is also a change in the likelihood of the punishment. Even when the interest is not in separating these effects but in analyzing them together, endogeneity problems are inherent to any empirical study that uses variations between locations or variations in time to identify deterrence effects. These problems are mainly caused by simultaneity because places and periods with greater crime levels tend to have more severe punishments, and by omitting relevant variables because it is challenging to control all the variables associated with punishment severity and the number of crimes. For example, the behavior of judges regarding punishment established by legislation affects both the number of crimes and the willingness of legislators to change legislation on punishments.

Alternatives found in the empirical literature are the search for natural experiments and quasi-experiments. For example, changes in laws and government policies can generate exogenous variations that allow the data in the sample to be separated into control and treatment groups so that observational studies can be approximated into controlled experiments. In other words, although there are no random samples, research designs are sought to generate selections from these groups that are as good as if they were random. In this context, to evaluate the impacts that changes in punishment severity have on crimes, the use of both natural experiments and quasi-experiments can be seen in the literature.

Kessler and Levitt (1999) used the natural experiment generated by Proposition 8, approved in California. This proposition increased the punishment severity for reoffending criminals by adding five years for each crime committed previously if it was a violent crime and one year for each previous crime if it was non-violent. These new rules were applied to homicide, rape, robbery, attempted murder with firearms, and burglary (treatment group). However, the previous legislation was maintained for the crimes of attempted homicide without the use of firearms, vehicle theft, and other thefts (control group). Their results indicated that the treatment group's crimes plummeted in the first year of the proposal due to deterrence effects and continued to fall in subsequent years. According to the authors, this result was due to the combination of the effects of incapacitation and dissuasion.

¹¹ It should be noted that the likelihood of punishment used in the economics of crime models is that which is perceived by the individual, which is not necessarily the true one. Bebbchuk and Kaplow (1992) showed that more severe punishments are inefficient when individuals have imperfect information about punishment probability.

Helland and Tabarrok (2007) used the quasi-experiment generated by the Three-Strikes Law in California. In this law, punishment severity changes abruptly from the second to the third strike. Criminals can be divided into two groups: one group of criminals who reoffended after the first crime (control group) and the other group of those who reoffended after the second crime (treatment group). After analyzing crimes in California, the authors concluded that the legislation reduced recidivism by 48% after the first strike and 12.5% after the second strike. In other words, more severe punishments can generate an anticipatory effect that reduces crime upon the first strike.

Drago *et al.* (2009) used the natural experiment generated by the Collective Clemency Law that the Italian parliament approved in July 2006. This law established a reduction of three years in the sentences of those convicted. It also determined that, in the case of recidivism, criminals must receive the residual punishment for the crime whose sentence had been reduced in addition to the sentence imposed by the new offense. Thus, each potential act of recidivism would have a different punishment. Using these other punishments as a source of exogenous variation, the authors concluded that each month of an additional (residual) sentence reduces the likelihood of recidivism by 1.24%.

Closely related to us, Lee and McCrary (2017) used a quasi-experiment generated for the age of criminal responsibility. This legal device increases punishment severity, separating a sample into two groups. The first group would consist of minors (control group) who receive softer punishments, while the second group would be adults who receive more severe punishments (treatment group). Using a longitudinal database that tracked the “criminal career” of various individuals in Florida between 1989 and 2002, the authors found a reduction of 2% in recidivism (outcome variable) for an increase in punishment estimated at 230%.

However, the study had some limitations that also appear in related studies. The results were severely affected by incapacitation effects. Many convicted for the first crime did not re-offend because they were still serving prison sentences, especially if the first offense was serious and severely punished. This is a limitation of every study that uses recidivism data and studies that gather data from too short a time interval to recidivate. Secondly, grouping arrests for crimes with different punishments makes it impossible to obtain specific comparative crime statistics, such as how many homicides can be reduced with increased punishment severity.¹² For example, the FBI’s classification for violent crimes includes homicide, attempted homicide, rape, and robbery. Besides having very different punishments under any penal code, the number of robberies is generally much higher than other crimes. We show this for the Brazilian case in which variations in the number of robberies almost exclusively determine variations in the total number of violent crimes.

Also, using Lee and McCrary’s (2017) methodology, Costa *et al.* (2018) tried to overcome this considerable limitation using a proxy variable for the number of crimes: the number of homicides by age in Brazil provided by victimization data (death records). According to the authors, this variable would overcome the problems caused by the underreporting of crimes. In

¹² Loeffler and Grunwald (2015) evaluated recidivism probability through the quasi-experiment generated by the law of the State of Illinois using four-year data from drug felonies in the city of Chicago. The authors found that processing juveniles as adults reduced recidivism probability by 3 to 5 percent. Since they used data from a single felony that is not usually punished severely for first offenders, their study was not limited by the problems generated by the aggregation of crimes or by the presence of incapacitated individuals in the sample.

other words, the study assumed that the profile of the criminals would be very similar to that of the victims of this type of crime. Faced with possible criticism about the use of this proxy, the authors complemented the study by using information about four years of arrests in the state of Rio de Janeiro, which were aggregated into four categories (violent index crimes, property index crimes, drug-related non-index crimes, and other non-index crimes) by their severity. Considering this proxy and the crime aggregations, the authors did not find a significant reduction in the number of homicides or arrests for violent crimes, crimes against property, or other minor crimes. However, they found a decrease in drug-related crimes.¹³

3. INSTITUTIONAL BACKGROUND

Similar to Lee and McCrary (2009), Loeffler and Grunwald (2015), and Costa *et al.* (2018), we use the quasi-experiment generated by the parallel existence of two criminal laws that cause discontinuity in punishment severity at 18 years of age. In Brazil, individuals younger than 18 are governed by the Statute of the Child and Adolescent, which provides seven types of warning and punishment that last from 0 to 3 years. The most severe punishment is juvenile incarceration. In this case, crimes are treated as infractions; therefore, they do not count as cumulative crimes for the individual's adult life. In other words, and as mentioned before, at 18 years of age, all Brazilians are considered first-time defendants. In turn, those older than 18 are governed by the Penal Code, which prescribes three punishment regimes (open, semi-open, and closed), lasting 0 to 30 years.¹⁴

Therefore, the existence of these two regimes for the same infraction/crime means differences in punishment severity. However, these differences are not the same for all crimes. In crimes with lower offensive potential, the punishments tend to be soft or inexistent. For example, in the case of theft, it is improbable that incarceration (in a juvenile facility) would be applied to minors because this type of measure prioritizes cases involving violence.¹⁵ Article 155 of the Penal Code prescribes incarceration from one to four years and a fine for this same crime. However, if the convicted person's sentence is less than two years, this provision may be suspended for two to four years, provided that the convicted person is not a reoffender. If the sentence is between two and four years of incarceration, the convicted person may serve this sentence under the open regime if they are not a reoffender.¹⁶ We use these types of crime with no significant discontinuity in the severity of punishment as a placebo.

¹³ In addition to the limitation imposed by the use of questionable proxies, the number of homicides and the victims' age, and the grouped data, the study combined the use of a log transformation of the data with nonlinear models (polynomials of high order) which made it impossible to know what the estimated coefficients actually mean.

¹⁴ Recently, Law 13,964/2019 raised the maximum penalty to 40 years.

¹⁵ According to a survey by the National Socio-Educational Service System from 2016, approximately 3% of juvenile incarcerations were due to theft cases. This survey showed that almost 66% of incarcerated youths are affected by this measure due to infractions against people. The survey can be accessed from the following link: http://www.mdh.gov.br/todas-as-noticias/2018/marco/Levantamento_2016Final.pdf (last accessed September 2020).

¹⁶ A similar situation occurs with other quite frequent crimes, such as assault and threat. These crimes are defined in articles 129 and 147 of the Penal Code that prescribes imprisonment for three months to a year and one month to six months, respectively. In other words, as for the crime of theft, first-time offenders will probably have their sentence suspended or served in the open regime.

In the case of heinous crimes, such as drug trafficking and homicide, soft punishments change significantly. For these crimes, convicted people must start their sentence in the closed regime, and regime progression occurs under more stringent conditions: the progression for first-time offenders occurs after 2/5 of the sentence in a closed regime (with stricter conditions for re-offenders), while for other crimes it occurs after serving 1/6 of the sentence. Table 1 compares the maximum penalties applied to minors with the minimum penalties applied to adults to estimate the differences in punishment severity between the two legislations (the Statute of the Child and Adolescent and the Penal Code) for these crimes. As evidenced, despite juvenile incarceration not being perfectly comparable to adult imprisonment, in practice, the length of incarceration would be approximately six times higher in terms of time served under the Penal Code for both drug trafficking and homicide.

INSERT TABLE 1 HERE

A relevant issue is that it cannot be guaranteed, a priori, that the punishment probability is the same above and below the age threshold for the crimes we are considering. Arora (2019) drew attention to the fact that, in general, there may be a rate of underreporting of underage offenses. This situation would lead to underestimating the effects of increased punishment severity with the age of criminal responsibility. In the case of drug trafficking, it may be realistic to assume that police officers do not record a certain percentage of crimes for either minors or adults due to the insignificance of the amount of drugs possessed. One cannot rule out the possibility of a priori differences between this underestimation. This would result in differences in the likelihood of punishment among minors and adults for this type of crime. In the case of drug trafficking, in principle, one could expect a change in (under)reporting behavior of police officers (with more leniency towards minors). Hence, the incentives faced by adults in terms of the probability and severity of punishment go in the same direction. In the case of homicides or homicide attempts, it is not plausible to suppose that police fail to record these crimes for whatever reason or reduce their effort to arrest suspects if it is determined that the person responsible is a minor (see Lee and McCrary, 2017). Thus, in this case, stability is expected in the punishment probability, which enables a more accurate estimation of the effects of the change in punishment severity.

4. DATA AND METHODOLOGY

The database used in this study includes all the police (civil and military) arrests in the state of Rio de Janeiro during 2016 and the first half of 2017. During this period, 59,117 total arrests were made, for which there is information about the type of crime and the date it occurred, as well as information about the suspects, such as their date of birth, sex, race, and the municipality of origin (see Table A1 in the appendix for the main crime categories).

We focus on drug trafficking crimes and homicides (see Figure 1). From a statistical point of view, the occurrences of homicides among youngsters aged 17–19 were not enough to provide robust estimates regarding the number of observations. Hence, at the cost of losing a clear downward jump at the cut-off age observed for homicides (see Figure A.2 in the

appendix), we aggregate homicides and homicide attempts to gather enough information to estimate the non-parametric models.

Figure 1 shows that arrests for drug trafficking and homicides (including attempts) peak between 16 and 19 years of age. In the histogram, the data is aggregated by year. Behavior around 18 years of age may vary, and a more formal evaluation is necessary. Potential differences in socio-economic characteristics and psychological development mean that these groups cannot be treated as equal without proper controls for these differences. The problem is that information about these features is rarely available. In this context, a Regression Discontinuity Design is a robust methodology that consists of a non-experimental approach in which the assignment of treatment of an individual is continuously linked to a measurable exogenous variable/characteristic that enables control and treatment groups to be separated based on a cut-off. In other words, for our identification strategy of local treatment effects, the discontinuity that matters is total arrests by age in the vicinity of 18 years old and not arrests aggregated by year of age.

INSERT FIGURE 1 HERE

The application of this method depends on the choice of a continuous classification variable. According to Cattaneo *et al.* (2018), non-parametric methods for estimating local polynomials are not applicable when the choice variable is discrete unless the probability mass points have a large amount of information. This problem is evident when the total number of crimes (arrests) by age is used. Over a year, there are 365 possible dates for individuals to be arrested. However, there may be a reasonable number of dates without crimes (i.e., with values missing), or there may also be a problem if the number of arrests is not large enough each “day” so that one does not have the information per mass point needed to perform a local polynomial estimation.¹⁷ Alternatively, we use the total number of homicides (including attempts) and drug trafficking crimes for a seven-day interval (bin). Even though this empirical strategy implies a loss of variability in the data, it gives us enough observations to estimate a local polynomial model with reasonable confidence. Thus, the estimated local effect of the treatment informs us whether the total number of arrests for homicides/drug trafficking increases or decreases with the age of criminal responsibility.

A requirement to ensure method robustness is for the classification variable not to be caused or influenced by the treatment. In our case, it is quite plausible that this requirement is satisfied because the individuals included in the sample cannot decide which group they will be because their age (running variable) is defined exogenously. In other words, suspects cannot choose which punishment regime they are subjected to, as this is determined by their age, over which they have no control. Additionally, it should be assumed that discontinuity at the cut-off point is due only to the change in treatment status. When there are covariates, the other variables should show smooth (and continuous) behavior during the observations. There should be no

¹⁷ To overcome this problem, Lee and McCrary (2017) used recidivism as an outcome variable instead of the total number of crimes. That is, the entire sample is used. Zero is assigned to the criminals who did not re-offend and those who re-offended. Thus, there is a sufficiently large amount of information to treat the age variable (discrete) as if it were continuous.

differences between individuals near this threshold beyond receiving or not-receiving this treatment.

Another sensitive point of this method is the choice of functional forms and bandwidths. Information is required on what appropriate form should be used for the relationship between the outcome variable and the classification variable, which information interval in the neighborhood should be included in the estimation, and how much information should be included in each bin. All of this information is necessary to estimate the non-parametric models. In this latter case, there is a trade-off between bias and variance, in which smaller bandwidths have a smaller bias. However, a larger bandwidth means greater variance. Thus, several authors have proposed methods for obtaining a bandwidth that minimizes the estimates' bias and variance (Ludwig and Miller 2007; Imbens and Kalyanaraman 2012; Calonico *et al.* 2014).

INSERT FIGURE 2 HERE

Figure 2 provides a preview of our estimates. It shows non-parametric estimates in a second-order polynomial for total arrests for drug trafficking and homicides (including attempts). Thirty bins are used to the right and the left throughout the classification variable (age) in an interval with one year more and one year less than the cut-off point (18 years of age). The identification strategy is based on separating arrests into two groups (treatment and control) to estimate non-parametric models for each of them so that they could be extrapolated to the cut-off point to simultaneously obtain the values of the treatment group and the control group. The difference (at the dashed vertical line) is the local average treatment effect.

As shown in Figure 2, there is a positive trend in drug trafficking arrests before 18 years of age, with a subsequent decline and change in this trend after the threshold. The confidence intervals for this model are narrow since there are many more observations for this crime than for others. The total number of homicides is more dispersed, and it is difficult to observe any trend or functional form before the estimation. However, a second-order polynomial model shows an increase starting six months before 18 years and a significant jump down after 18 years of age. However, these results should be viewed cautiously, given that the estimates do not consider the optimal bandwidth choice. In the present study, optimal bandwidth choice follows the procedures proposed by Calonico *et al.* (2014; hereafter, CCT), and the results presented in the next section follow only these procedures.

4.1. Potential threats to our identification strategy

Given our setup, we are aware that some other factors also change in Brazil at 18 years of age. They could be seen as potential confounding factors of the results we obtain for the age of criminal responsibility. These factors relate to the emancipation of individuals that entail the right to drive, the possibility to buy legal drugs (such as alcohol), and the possibility to work in activities of any nature. Next, we discuss if they present a threat to our identification strategy.

The ability to drive may help commit crimes, such as facilitating drug transportation, creating an alternative form of escape from a murder scene, or just making it easier to commit crimes in places farther away from home. However, it is unclear whether a driver's license is

relevant. In Brazil, the vehicle's owner is responsible, so there is no punishment for driving without a license if there is no identifiable owner. Besides, it is important to remark that to acquire a driving license in Brazil is necessary to take mandatory lessons in a specialized driving school and take a practical examination to obtain a restricted-use temporary permit. It is expensive considering the Brazilian income standard, and takes at least four months. If additional lessons are necessary, it takes another six months. It means that most of our used windows are narrower than in this period, so our results would be, in principle, not affected by issuing driver's licenses. Licensed drivers are also a small share of the population. The data from *Departamento Nacional de Trânsito* (DENATRAN) confirms that driver's licenses are not common at early ages and shows that only 13.56% of the population under 21 years old had a driver's license at the end of the year 2017 in the state of Rio de Janeiro.¹⁸

The relationship between alcohol and crime is well known in extensive literature that describes a positive correlation between violent crimes and alcohol abuse (Boles and Miotto, 2003; Dingwall, 2013). Even though the theory suggests an effect in the opposite direction that we are trying to measure, it may be a threat to the validity of our results because it would reduce the magnitude of our estimated treatment effects if youngsters under 18 may commit fewer crimes than their potential and who achieved the majority age may commit more crimes due to alcohol consumption. However, youngsters buying and consuming legal drugs such as alcohol is common in the whole country, and Rio de Janeiro is no different. The data obtained from the survey called *Pesquisa Nacional de Saúde* shows that the share of the population who declares to consume alcohol at least once a month does not change abruptly from 17 to 18, but 16. At 16 years old, nearly 21% of youngsters declare to consume alcohol regularly, while 37% and 41% report at 17 and 18 years old, respectively.¹⁹

Finally, legal opportunities to work may have important deterrence effects on crime (Chalfin and McCrary 2017). In Brazil, the age to work legally is 16, but with some restrictions. For instance, it is strictly forbidden for young individuals to work at night or in dangerous or unhealthy situations. From 18 years onwards, such restrictions do not apply. However, the data in Figure A.3 in the appendix shows that only a small share of youngsters was working in legal activities in the state of Rio de Janeiro in the same period of our sample, and there is not an abruptly identifiable jump in this share at the age of 18. Actually, the data shows the expected increase in the workforce with age. Still, with more significant jumps starting at 19 years old, this evidence indicates that we can discard that the discontinuity changes in crime practices are due to work law changes.

5. RESULTS

The results presented in Table 2 (drug trafficking) and Table 3 (homicides including attempts) are estimated with two polynomial orders. Generally, they show a significant negative treatment effect in all the estimated models.

¹⁸ Source: <https://www.gov.br/infraestrutura/pt-br/assuntos/transito/conteudo-denatran/estatisticas-quantidade-de-habilitados-denatran>

¹⁹ See Figure A.3 in the appendix.

In the case of drug trafficking (Table 2), an increase in punishment of incarceration in a juvenile facility for a maximum of three months to a minimum prison sentence of five years (which may or may not be served in the closed regime) reduces the number of arrests by between 3.1% and 9.1%. Note that this result should be considered with caution since there could be two forces with opposite signs acting on the total arrests of juveniles that cannot be observed. First, we cannot rule out the possibility of underreporting this crime for juveniles, as described by Lee and McCrary (2017) and Arora (2019), reducing the observed total arrests below 18 years old. Second, it is very common for juveniles to assume that the crime of drug trafficking is committed by adults because their punishment is very soft compared to that of adults.

For homicides (including attempts; Table 3), an increase in punishment severity from nine months of incarceration in a juvenile facility to at least four years and ten months in a closed regime prison reduces total arrests for homicides by between 34.94% and 39.72%. For homicides, underreporting is expected to be very low, and the incentive for juveniles to assume the crime of homicide committed by adults is lower than for drug trafficking because of the punishment of juveniles. However, it is still lower than an adult's; it is not close to zero.

We analyze the robustness of these results by first evaluating the existence of discontinuities at other ages close to the cut-off age (Table A.2 for drug trafficking crimes and Table A.3 for homicides, including attempts, in the appendix). The results indicate no significant reduction in the total arrests for drug trafficking and homicide at 17 or 19, considering the three sample arrangements. For homicides, the hypothesis that all estimated coefficients are zero could not be rejected, while for drug trafficking, the coefficients are positive and significant in all linear models. However, most of these positive jumps disappear in non-linear models. The only exception is the model that considers only the first offense in our sample, which shows a significant positive jump at the age of 17, probably due to the positive trend observed in the arrests for drug trafficking before the penal majority.

INSERT TABLE 2 HERE

INSERT TABLE 3 HERE

The second robustness exercise uses other crimes for which there are no significant differences in punishment severity. Considering all observations, the results for thefts, threats, and assaults indicate that, as expected, there is no substantial reduction in these crimes at the age of criminal responsibility (see Table A.4 in the appendix). In fact, in these cases, the punishments were very soft or almost inexistent for both groups (treatment and control). However, there is an increase in the total number of robberies, which may be an indication that the actual punishment severity applied to minors close to 18 years of age for this type of crime may be greater than that applied to adults who are “first-time” offenders, as criminal records are deleted when individuals turn 18 years of age.²⁰

²⁰ For robberies, the punishment provided by article 157 of the Brazilian Penal Code is the incarceration of four to ten years. However, if this punishment is less than eight years and if the defendant is a first-time offender, the sentence may be served in the semi-open regime. Therefore, there is no punishment in a closed regime. For minors, the punishment of juvenile incarceration for this crime is unlikely to be applied for the first infraction. Still, when

Our main results differ somewhat from those of Lee and McCrary (2017) and Costa *et al.* (2018). Regarding the first study, the differences are only about magnitude. There are no differences concerning the sign or significance of the estimated local average treatment effects. Regarding the second study, the differences are statistically significant, given that the authors did not find significant impacts of the increase in the severity of punishment due to the age of criminal responsibility for violent crimes. However, they found significant negative impacts for drug-related crimes, as we do in the present study.

One possible explanation for the differences in magnitude between this study and that of Lee and McCrary (2017) is that both Lee and McCrary (2017) and Costa *et al.* (2018) grouped violent crimes. This empirical strategy may produce misleading conclusions about the deterrence effects of increasing punishment severity. This is the most common violent crime (as shown in Figure A.4 of the appendix). Therefore, the non-significant impact of violent crimes found by these authors, especially Costa *et al.* (2018), who used a database similar to ours, is the result of aggregating crimes with quite different numbers of arrests and punishment severity.

6. DISCUSSION AND CONCLUSIONS

This article uses a quasi-experiment generated by the age of criminal responsibility in Brazil to evaluate the impacts of increased punishment severity on two types of crime: drug trafficking and homicides. These crimes were chosen because they significantly differ in punishment severity between minors and adults in Brazil. They are closely related to drug trafficking gangs in Rio de Janeiro. The results indicated a significant reduction in the total number of these crimes with the increase in punishment severity in the Penal Code. Therefore, it can be concluded that, in the particular setup of Rio de Janeiro, increasing punishment severity, *ceteris paribus*, would reduce these crimes and engagement in criminal activities. These results differ from studies that used similar methodologies, such as Lee and McCrary (2017) and Costa *et al.* (2018). However, they agree with those of other authors such as Kessler and Levitt (1999), Helland and Tabarrok (2007), Drago *et al.* (2007), and Loeffler and Grunwald (2015), who also used robust methods (i.e., based on natural experiments and quasi-experiments).

This empirical study differs from its predecessors by analyzing the crimes in a non-grouped manner. This enables more precise estimates of crime elasticities concerning punishment severity and outlines a counterfactual scenario of what would occur if there were a reduction in the age of criminal responsibility for these crimes. The results indicate that an increase in the detention period of approximately one year and nine months (or 800%) for drug trafficking and four years (or 500%) for homicides, respectively, combined with the more inhospitable environment of prisons, can reduce drug trafficking and homicide crimes, assuming that there is stability in the percentage of arrests per crime, by approximately 9% and 37%, respectively. These elasticities appear to be very low, considering the required percentage increase in the detention period.

applied (for recidivists) in the state of Rio de Janeiro, it is usually for five months of detention in a juvenile facility. So, at least for robbery, the punishment severity may be more severe for juveniles than for adults since a detention period is more likely to be sentenced for juveniles than for adults.

However, regardless of these aspects, it must be emphasized that the results obtained in this study indicate that, *ceteris paribus*, the most severe punishment provided by the Penal Code, leads to a reduction in the total number of arrests for the crime of homicide. Assuming that there is stability in the percentage of arrests per crime, there would also be a reduction in the number of arrests (which would further reduce the cost of applying the measure) and in the number of homicides (which would increase the benefits of the measure), due to the deterrence effects of this more severe punishment. Therefore, even in the most pessimistic scenario, some lives are expected to be saved and some criminal careers interrupted so that the benefits far outweigh the costs of applying more severe punishments to minors in the case of homicides, regardless of the method of application, whether in the form of incarceration in a juvenile facility or an adult prison.

This net benefit observed in the case of homicides is most likely not observed in the case of drug trafficking. This difference is probably because, besides the low impact of the harsher punishments imposed by the age of criminal responsibility on the total arrests for this crime (a reduction of approximately 9%), it is unlikely that arrests for drug trafficking will lead to a reduction in the occurrence of this type of crime. After all, others quickly and easily replace detained criminals. In this context, an increase in punishment severity suggests a higher cost for potential criminals, who will have to be compensated financially for this higher expected cost. Thus, recruiters of juveniles will have to spend more resources on the drug trafficking workforce. It is possible that equalizing punishment severity between minors and adults will reduce the number of youngsters involved in this type of crime, which would help solve the problem in Rio de Janeiro regarding using minors as sellers and soldiers for drug trafficking. However, it cannot be ignored that psychological differences make youngsters (minors) more prone to crime. Therefore, it cannot be concluded that only increases in punishment severity can deter youngsters from crime, particularly a crime with high financial returns, as is the case with drug trafficking. There is evidence of public policies that are more effective in achieving this objective and are applied in childhood and adolescence in the rest of the world.²¹

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²¹It is worth mentioning a very successful program in the city of Chicago titled "Become a Man," which applies cognitive therapy to youngsters. The results of this study — which can be seen in Heller *et al.* (2017) — show a reduction in total arrests between 28 and 35%, a reduction of 45 to 50% in arrests for violent crimes, and an increase of 12 to 19% in completion of education levels.

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Appendix

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Table 1. Differences in punishment severity, by Brazilian legislation, for drug trafficking and homicide crimes.

		Drug trafficking (Art. 33, Law 11,343/2006)	Qualified homicide (Art. 121, Penal Code)
Statute of the Child and Adolescent (< 18 years)	Punishment prescribed	0 to 3 years	0 to 3 years
	Progression rule	Summary statement 492 of the Superior Court of Justice: there is no requirement for incarceration in a juvenile facility for the first infraction	No specific rule
	Actual punishment	Only 17% receive sentences of incarceration in a juvenile facility, which are rarely longer than 3 months	9 months of juvenile incarceration
Penal Code (> 18 years)	Punishment prescribed	Incarceration of 5 to 15 years and payment of a 500 to 1,500 day fine	Incarceration of 12 to 30 years
	Progression rule	2/5 of the sentence	2/5 of the sentence
	Actual punishment	2 years of incarceration ²²	4.8 years of incarceration

Note: homicide attempts are the intention to kill, but the goal is not achieved. The punishment in the Statute of the Child and Adolescent is also 0 to 3 years, with an actual punishment far below the 9 months observed for homicides. For adults, the Brazilian Penal Code prescribes a reduction of 1/3 to 2/3 in case of an attempt, but even if a sentence is cut by the maximum, 2/3, the minimum sentence would be 4 years with at least one year and seven months in a closed regime.

²² However, the punishment for first-time offenders may vary according to the judge's discretion. In addition, an offender may serve the sentence in an open regime since the Brazilian Supreme Court decision that could be a possibility if the defendant is caught with a small amount of drugs, has a good background, and does not belong to a criminal organization.

Table 2. Local average treatment effect on the total of arrests and on the percentage of arrests for the crimes of drug trafficking.

Polynomial order	All observations	Percentage variation	Excluding adults' re-offenses	Percentage variation	Only first offense	Percentage variation
1	-3.235*** (0.3982)	-4.49%	-3.184*** (0.3890)	-4.28%	-2.295*** (0.4030)	-3.12%
Bandwidth (h)	0.346 (4.1 months)		0.266 (3.2 months)		0.526 (6.3 months)	
2	-5.845*** (0.5600)	-8.58%	-5.944*** (0.5745)	-8.74%	-6.236*** (0.6416)	-9.10%
Bandwidth (h)	0.275 (3.3 months)		0.274 (3.3 months)		0.250 (3 months)	

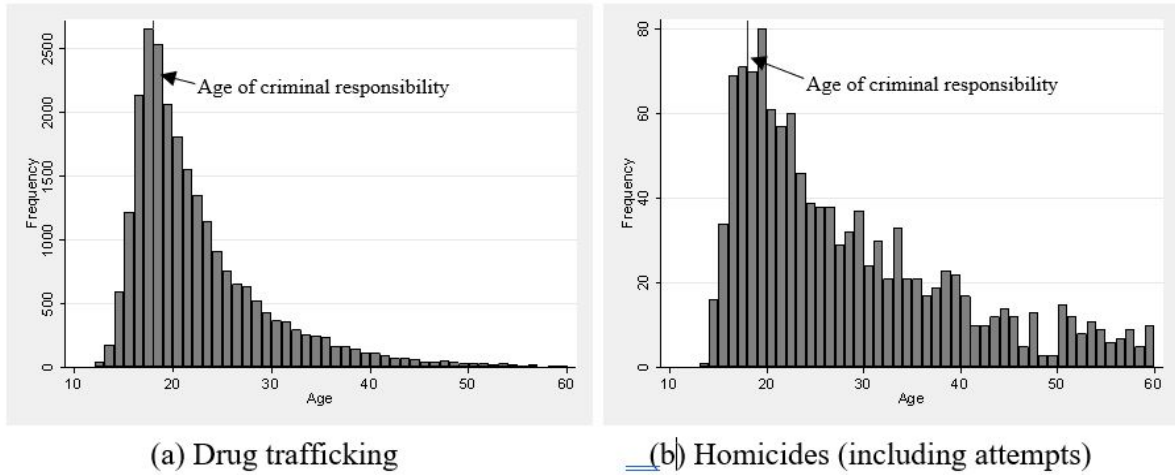
Notes: entries are the local average treatment effects using the CCT to select the bandwidth, with the standard errors shown below in parentheses. The values indicated in the bandwidth refer to the intervals below and above 18 years of age. The first column indicates the polynomial order used in the non-parametric estimation. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 3. Local average treatment effect on the total of arrests and on the percentage of arrests for the crimes of homicide.

Polynomial order	All observations	Percentage variation	Excluding adults' re-offenses	Percentage variation	Only first offense	Percentage variation
1	-1.8432*** (0.6410)	-35.03%	-1.9772*** (0.5778)	-39.72%	-1.4294** (0.7105)	-34.94%
Bandwidth (h)	0.422 (5 months)		0.492 (5.9 months)		0.671 (8 months)	
2	-1.8757*** (0.5973)	-37.62%	-1.9466*** (0.5944)	-39.61%	-1.6206** (0.8440)	-37.00%
Bandwidth (h)	0.927 (11 months)		0.998 (12 months)		1.107 (13.2 months)	

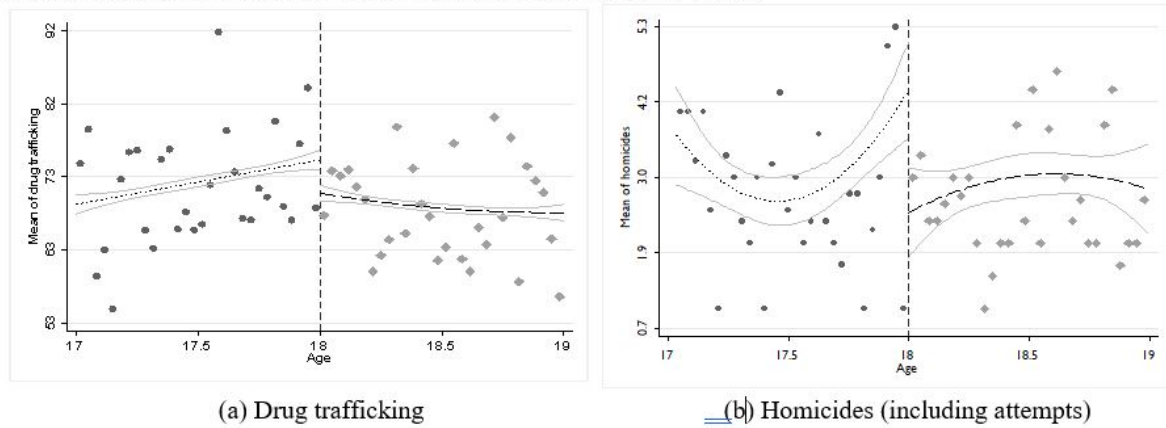
Notes: entries are the local average treatment effects using the CCT to select the bandwidth, with the standard errors shown below in parentheses. The values indicated in the bandwidth refer to the intervals below and above 18 years of age. The first column indicates the polynomial order used in the non-parametric estimation. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 1. Distribution of arrests by age for drug trafficking and homicide (including attempts) in the state of Rio de Janeiro (2016–2017).



Note: these figures are obtained using as an outcome variable the arrests of individuals when they appear for the first time in our data set. The figures for each crime independently of the offender and adults' first offense only can be found in Figure A.1 in the appendix.

Figure 2. Second-order local polynomial regression of total arrests for drug trafficking and homicide crimes in the state of Rio de Janeiro in 2016–2017.



Note: these figures are obtained using as an outcome variable the arrests of individuals when they appear for the first time in our data set. The figures for each crime independently of the offender and for adults' first offense only are practically identical (not reported but available upon request).

Table A.1. Total arrests by type of crime in the state of Rio de Janeiro (2016–2017).

Crime type	#	%
Assault	2,365	4.0%
Drug trafficking	33,570	56.8%
Extortion	109	0.2%
Homicides + attempts	1,608	2.7%
Rape	249	0.4%
Robbery	12,191	20.6%
Swindle	277	0.5%
Theft	7,433	12.6%
Threat	1,315	2.2%
Total	59,117	

Table A.2. Falsification tests: drug trafficking.

Polynomial order	Age	All observations	Excluding adults' re-offenses	Only first offense
1	17	2.7199*** (0.4263)	3.9318*** (0.4192)	2.6323*** (0.4784)
	Bandwidth (h)	0.328 (3.9 months)	0.269 (3.1 months)	0.326 (3.9 months)
2	17	0.5431 (0.7212)	0.8644 (0.7186)	4.6775*** (0.8125)
	Bandwidth (h)	0.178 (2.1 months)	0.182 (2.1 months)	0.201 (2.4 months)
1	19	3.8332*** (0.4284)	2.858*** (0.4875)	2.8588*** (0.4876)
	Bandwidth (h)	0.092 (1.1 months)	0.097 (1.1 months)	0.097 (1.1 months)
2	19	0.7801 (0.4767)	-0.0611 (0.5148)	0.1578 (0.5264)
	Bandwidth (h)	0.195 (2.3 months)	0.213 (2.5 months)	0.202 (2.4 months)

Notes: entries are the local average treatment effects using the CCT method to select the bandwidth, with the standard errors shown below in parentheses. The values indicated in the bandwidth refer to the intervals below and above the age shown in the first column. *** p<0.01, ** p<0.05, * p<0.1.

Table A.3. Falsification tests: homicides (including attempts).

Polynomial order	Age	All observations	Excluding adults' re-offenses	Only first offense
1	17	1.0972 (0.7959)	1.1892 (0.8269)	1.0779 (0.9169)
	Bandwidth (h)	0.474 (5.7 months)	0.443 (5.3 months)	0.543 (6.5 months)
2	17	0.7476 (0.8865)	0.7727 (0.9010)	0.9845 (1.1169)
	Bandwidth (h)	0.812 (9.7 months)	0.793 (9.5 months)	0.799 (9.5 months)
1	19	-0.0263 (0.5256)	0.0021 (0.5243)	-0.0831 (0.5114)
	Bandwidth (h)	0.561 (6.7 months)	0.666 (8 months)	0.656 (8 months)
2	19	-0.2484 (0.7685)	0.6121 (0.7726)	0.9931 (0.929)
	Bandwidth (h)	0.619 (7.4 months)	0.613 (7.3 months)	0.575 (6.9 months)

Notes: entries are the local average treatment effects using the CCT method to select the bandwidth, with the standard errors shown below in parentheses. The values indicated in the bandwidth refer to the intervals below and above the age shown in the first column. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.4. Local average treatment affects the total arrests for thefts, robberies, threats, and assaults (all observations).

Polynomial order	Robberies	Thefts	Threats	Assaults
1	4.7645*** (0.3011)	0.6625 (0.4770)	-0.3398 (0.0.3277)	0.6279 (0.5540)
Bandwidth (h)	0.343 (4.1 months)	0.354 (4.2 months)	0.508 (6 months)	0.620 (7.4 months)
2	6.2137*** (0.3163)	0.5495 (0.4464)	-0.5308 (0.3886)	0.7431 (0.6639)
Bandwidth (h)	0.415 (5 months)	0.710 (8.5 months)	0.633 (7.6 months)	0.976 (11.7 months)

Notes: entries are the local average treatment effects using the CCT method to select the bandwidth, with the standard errors shown below in parentheses. The values indicated in the bandwidth refer to the intervals below and above 18 years of age. The first column indicates the polynomial order used in the non-parametric estimation. *** p<0.01, ** p<0.05, * p<0.1.

Figure A.1. Distribution of arrests by age for the crimes of drug trafficking and homicide (including attempts) in the state of Rio de Janeiro (2016–2017).

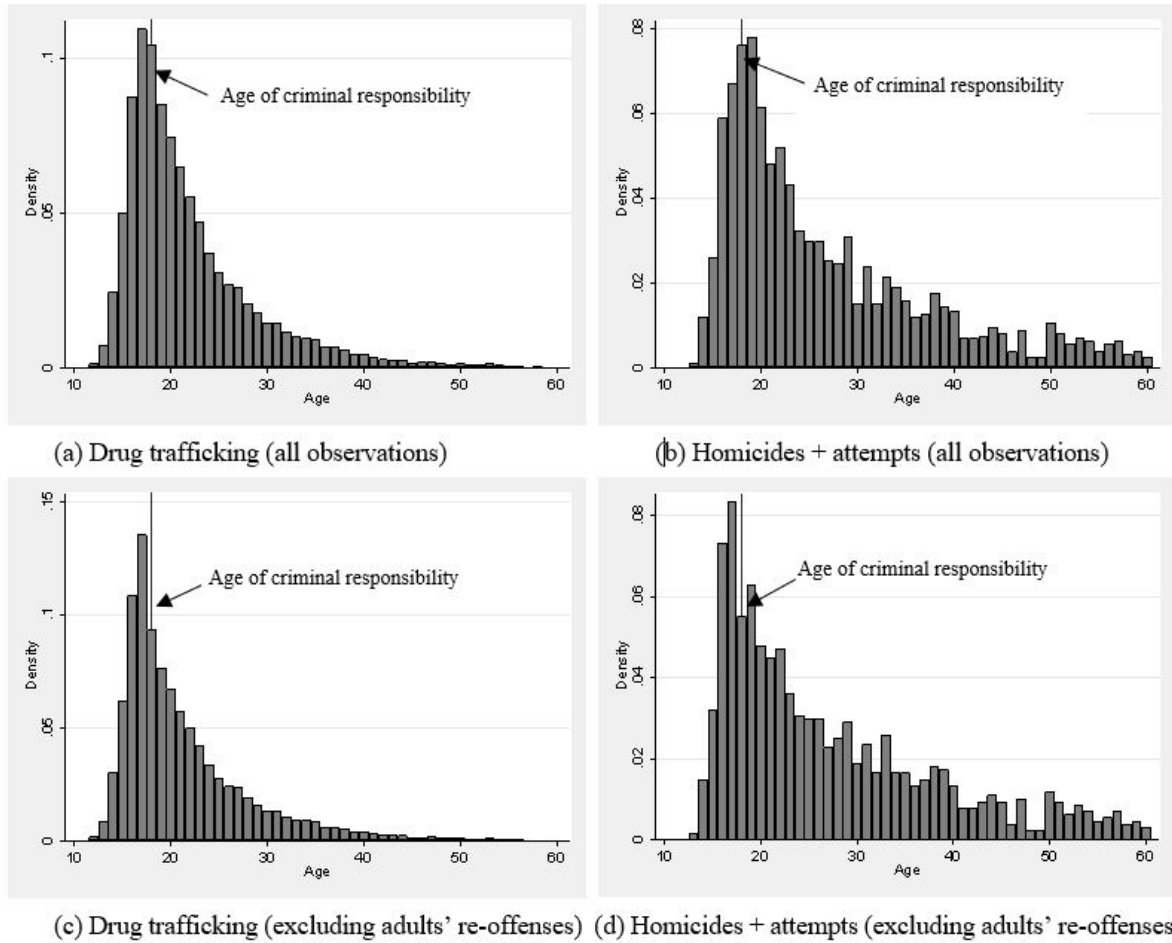
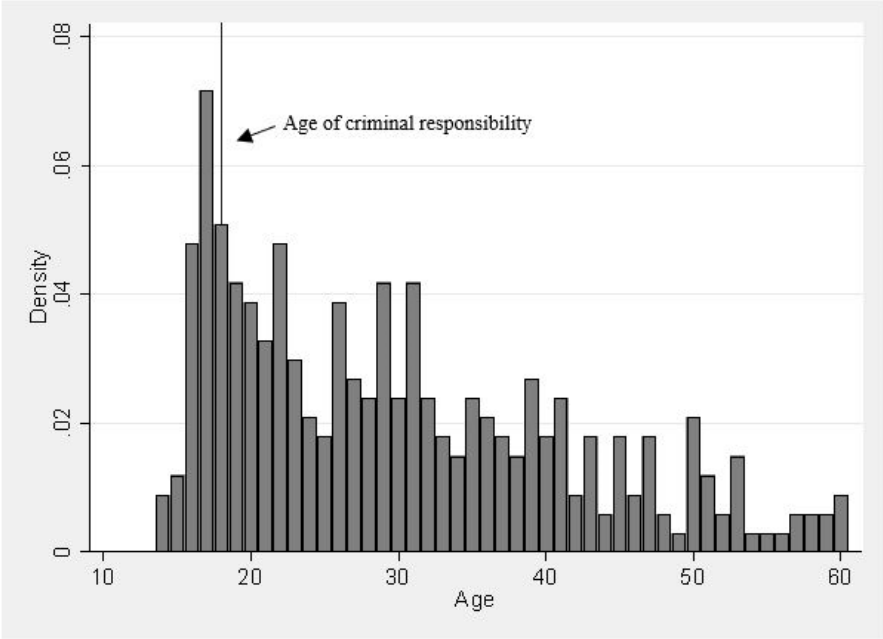
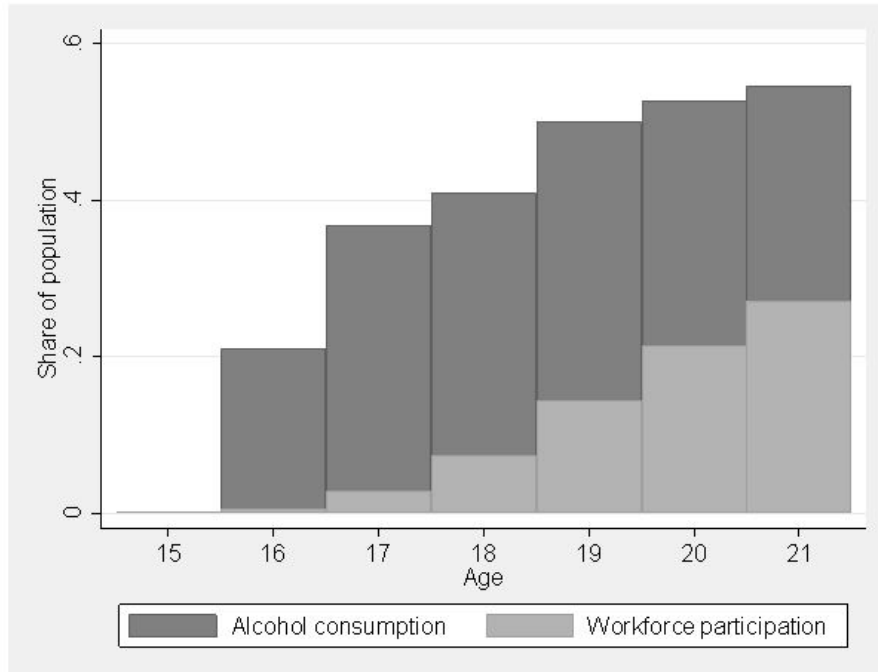


Figure A.2. Distribution of arrests by age for the crime of homicide (not including attempts) in the state of Rio de Janeiro, for 2016–2017.



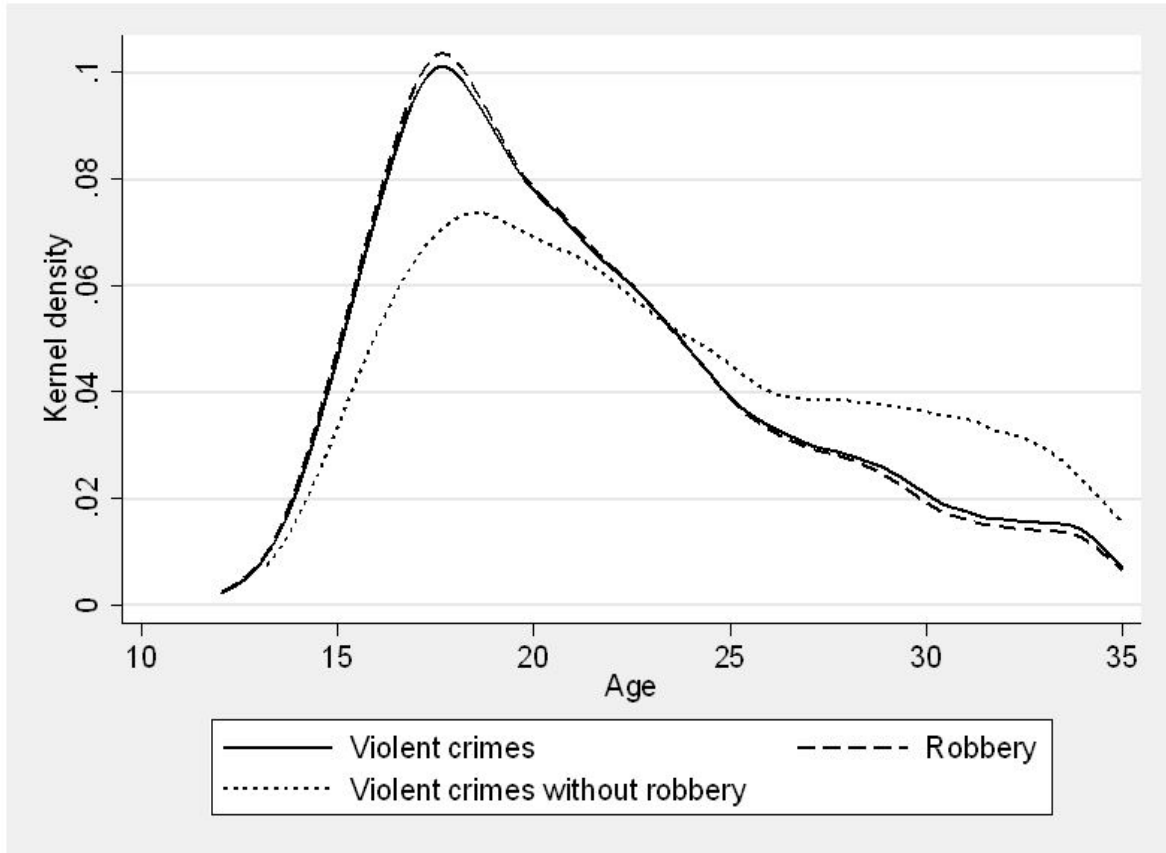
Note: Figure obtained using as the outcome variable arrests of individuals when they appear for the first time in our data set.

Figure A.3. Share of the population in the workforce and alcohol consumption by age at the state of Rio de Janeiro.



Notes: The workforce participation represents the share of the population working at the time of the interview. The source are six quarter surveys from *Pesquisa Nacional por Amostra de Domicílio* (PNAD) continua from the same period of our data, 2016-17, in the same state, Rio de Janeiro. Alcohol consumption represents the share of the population who declares to drink at least once a month. The source is the survey from *Pesquisa Nacional de Saúde* (PNS) from the year 2019 in the state of Rio de Janeiro.

Figure A.4. Distribution of arrests by violent crimes (homicides, robberies, aggravated assault, and rapes) and robberies by age in the state of Rio de Janeiro (2016–2017).



Note: figure obtained using as outcome variable the arrests of individuals when they appear for the first time in our data set.