Marco Antonio Jorge
Federal University of Sergipe
Economics Department, Center of Applied Social Sciences, Brazil
E-mail: mjorge@gvmail.br

SHORT TERM EFFECTS OF CANNABIS LEGALIZATION IN URUGUAY ON CRIME: AN ANALYSIS USING SYNTHETIC CONTROL

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Abstract

Uruguay is the only country in the world that has adhered to the legalization of marijuana production and distribution nationwide. The purpose of this paper is to analyze the short-term impacts of Uruguayan policy on crime (homicides and robberies) in that country, seeking to contribute to the literature by presenting the first results of this unique situation in the world. To do so, the paper employs the synthetic control methodology whose objective is to create a linear combination of the units of the donor pool, in this case the Brazilian states, mimicking the Uruguayan situation in the absence of the approved legislation. The results show that in spite of the fact that there has not been a trend break with regard to the two types of crime examined; a more exacerbated growth of both rates in the treated unit may have been avoided.

Keywords: Cannabis Legalization, Crime, Uruguay.

1. INTRODUCTION

In the year 2010, the US public sector spent about US$ 84 billion only on combating drug trafficking (the figure does not include spending on the police, prison system and federal agencies) (Lofstrom and Raphael, 2016). Despite the significant amount, 34 million Americans from 12 to 30 years of age reported using drugs in the previous 12 months in a 2005 survey (Wınter, 2008).

In addition, by 2015, an estimated 250 million people, or 5% of the 15-64 age group, have made use of at least one illicit drug, marijuana being by far the most consumed, by about 183 million individuals (World Drug Report 2017).

These data show that the immense effort made in the fight against drugs is not producing the expected results in the face of the cost involved, which rekindles the debate about the pertinence of the legalization of production and consumption of light drugs as an alternative strategy to control this market.

Thus, in the past five years, eight US states have legalized marijuana use for recreational purposes; recently Portugal decriminalized consumption, while Uruguay - a unique case in the world - adhered to legalization, transferring to the state the control and regulation of the importation, production, acquisition, storage, commercialization and distribution of marijuana or

its derivatives in the country, besides allowing the planting for own consumption of up to six feet, as well as the formation of farming clubs with between 15 and 45 associates (Uruguay, 2013).

While the consequences of such measures have been widely studied in the case of US states (Vidal, 2016, Hall and Weir, 2015, Addiction, 2016, Dragone et al, 2017, just to name a few), as far as we know there is no scientific study dealing with the Uruguayan case to the present moment.

Thus, the present study aims to analyze the short-term impacts of Uruguayan policy of regulating marijuana production and consumption on that country's criminality - especially on homicides and robberies -, seeking to contribute to the literature by presenting the first results of this unique case in the world (Uruguay).

To do so, the study makes use of the synthetic control methodology whose objective is to create a linear combination of the donor pool units - in this case the Brazilian states -, which seeks to portray with the greatest possible reliability what would be the situation in Uruguay in the post-intervention period in the absence of approved legislation.

The paper is organized in five sections besides to the present introduction: the first one presents the theoretical reference with emphasis on the consequences of the criminalization of drug use. The second section gives a brief description of recent Uruguayan drug policy. The third section presents the empirical strategy, the data used and their sources. In the fourth section we make a descriptive analysis and present the results as well as some robustness tests. Finally, in the last section the final considerations are woven.

2. THEORETICAL REFERENCE

In the case of marijuana, legalization of consumption and production may be restricted to medicinal and / or recreational purposes. In the first case, the consumption can only occur with a prescription and the purchase of the product is made in specific places: the dispensaries (in the case of the United States). Although the ban was enforced at the federal level, in 1996 California began legalizing marijuana for medical purposes.

Although Morris et al. (2014) found no relationship between legalization for medicinal purposes and increased crime - on the contrary, homicides and assaults showed a downward trend - dispensaries can be seen as interesting targets for criminals because of their availability of money and of good quality marijuana.

Thus, one can opt for the legalization of consumption and production also for recreational purposes. Currently, marijuana is legal for medical use in 28 US states, and among eight, marijuana is also legal for recreational use[1]. The first two states that adopted this second option (Colorado and Washington) did so in November 2012 and retail sales started in 2014.

In Colorado, marijuana can be purchased by residents and nonresidents aged 21 years or older up to one ounce (28.5g) for the first and 1/2 ounce for the latter. Domestic cultivation is allowed and the plants are chipped from cultivation to sale. Integration of the production chain is allowed, but advertising, consumption in public places and driving under the effects of the drug are not allowed. The tax is defined on the weight (and not on the power), with a rate of 15% on production and 10% on sale. Both cultivation for personal use and medicinal use are exempt (Vidal, 2016; Hall and Weir, 2015). Tax collection and taxes amounted to US$ 135 million in 2015.

In Washington, only residents under the age of 21 can purchase up to one ounce. It is not allowed to drive under the effect of the drug, as well as the domestic cultivation and the integration of the productive chain. The tax also is levied on the weight, but the rates differ: 25% on

[1] States that legalized recreational purposes account for about 20% of the US population. They are: Alaska (2014), California (2016), Colorado (2012), Maine (2016), Massachusetts (2016), Nevada (2016), Oregon (2014) and Washington (2012). The data in brackets refer to the year of approval of the law. (Drug Policy Alliance, 2016, updated by the author).

production, 15% on the wholesale and 10% on the retail (Hall and Weir, 2015). The first store opened in July 2014 (Addiction, 2016; Dragone et al, 2017) and the tax collection forecast for the first four years of legalization is about US$ 190 million (Drug Policy Alliance, 2016).

One feature of marijuana legalization processes is the delay in signaling significant changes: fifteen years after legalization for medical use in California, only 60 of its 336 districts had formally regulated marijuana dispensaries (Van Ours, 2012). By 2015 there were just over 300 licensed stores in Colorado (Vidal, 2016) and just over 2,000 people registered in the official Uruguayan registry (Vasconcelos Jr., 2015). Five districts (out of 39) in Washington did not permit legal consumption or had no registered retailers by the end of 2016 (Dragone et al, 2017).

That is, the pace of implementation of the legalization policy tends to be slower than expected due to the presence of inertia of personal habits and institutional structures, resulting from a long period of prohibition. According to Hall and Weir (2015), it would take a period of 5 to 10 years from the entry into force of legalization, to evaluate a possible effect of increasing dependence on the drug.

It is a fact that the prohibition of some activities increases their rate of return (eg, Robert, 2007), and stimulates their production, as in the United States in the period 1917-1933, when there was the prohibition of trade in alcoholic beverages[2].

Hellman and Alper (2006) mention that the estimated gain of the Colombian cartels in 1998 was about US$ 8 billion, which gives to the traffic a high power of corruption over the constituted authorities, as well as a high attractiveness to the producers. Lima et al. (2005), analyzing homicide rates in the state of Pernambuco (Brazil) in the period 1995-1998, find a negative correlation between poverty and that rate, which is unusual in the literature. For the authors, this is due to the hypothesis that "the production, distribution and sales of marijuana in the area of the polygon contributed to increase the average income of the population, which was previously undervalued with low cash crops, despite having provided conditions favorable to the increase in violence" (Lima et al, 2005, p. 181).

The highest return, however, does not translate into benefits for communities affected by trafficking. According to Gomes (2005, p. 16), "one fact is clear, crime installed in favela areas does not accumulate capital in these areas, there is no evidence to indicate any improvement in living conditions in these places."

On the contrary, the illegality of drug production and consumption leads to a sharp increase in violence and homicide rates. This increase occurs through three channels (Cerqueira, 2010): i. dispute over markets; ii. mechanism of compliance with contracts and inhibition of deviant behavior; and iii. fight against repression by the State.

In the first case, high returns from illegal activity attract a large number of bidders. However, these will operate in geographically limited territories, which provoke great incentive to the adoption of anticompetitive practices (Sieberg, 2005). In the absence of a legal system to regulate competition, the bidders will use violence as a strategy to demarcate their market, as well as will resort to the formation of gangs or mafias to increase their market power.

According to Dell (2015), in Mexico, government offensives against drug trafficking have escalated violence to the extent that i. rival gangs try to take control of territories where incumbent traffickers are weakened and ii. spillovers increase the likelihood of conflict with other traffickers.

For Rolim (2005) such disputes for geographical control make each group more dependent on firearms, insofar as it needs to arm on a larger scale than its competitors. Thus, there is an interconnection between drug trafficking and guns trafficking.

[2] The prohibition of alcohol began in 1917 as an emergency measure of war, becoming permanent in 1920 and lasted until the end of the year 1933, cf. Miron and Zwiebel (1995).

In the second case, a broken contract cannot be brought to the justice, and a defaulting consumer cannot be denounced to credit protection entities. In this way, violence is used to inhibit consumer cheating, especially in large cities where anonymity is greater, and of employees who could divert part of the drugs for their own consumption or for direct sale and argue that it would have been stolen or apprehended by the police.

Finally, it remains to mention the brunts with the repressive force of the State that have resulted in countless deaths from both sides around the world.

In addition, the deterrent effect of actions undertaken by the public sector tends to weaken for three reasons: a) Miron and Zwiebel (1995) mention that the cost curve of punishment tends to be concave, that is, the penalty increases less than the increase in the number of illicit acts; b) for Lofstrom and Raphael (2016) imprisonment presents decreasing returns of scale in the fight against crime in that it includes younger and criminally less active individuals and c) Prison may represent a low deterrent effect if conditions of incarceration are seen by individuals as not much worse than their daily lives (Dills et al, 2010).

Shepard and Blackley (2010), on the other hand, enumerate three more channels of connection between the prohibition of trafficking and the increase of crime: d) the greater allocation of resources in the fight against drugs diminishes the available inputs for the confrontation of other types of crime, which may lead to an increase in the latter; (e) the same reasoning applies to detention: the emphasis on drug-related imprisonment (users and dealers) reduces the availability of prison facilities to other types of offenders, and (f) the increase in drug costs, resulting from their prohibition, raises income necessary to maintain consumption, which may induce some of the addicts to commit crimes to obtain this income.

In this sense, the legalization of the production and consumption of light drugs, with the consequent regulation of the market, could be an interesting strategy to reduce the homicide rate and the corruption of the agents involved in the anti-trafficking actions. Sieberg (2005) lists some arguments in favor of legalization: i. State or private sector would take control of the market, removing it from organized crime; ii. Price reduction would discourage production and consequent recruitment by gangs / organized crime; iii. Illegality does not bring any incentive to cooperation with the authorities, since it is a victimless crime where both parties win with the transaction.

In addition, for Hellman and Alper (2006): iv. Legalization would allow to control the quality of the offered products, reducing the risks for the users; v. Regulation could restrict the access of teenagers to drugs, as in the case of legislation on alcoholic beverages; vi. Regulation would encourage users to seek help in case of abuse or drug addiction and vii. Economies of resources currently spent in the war on drugs, which could be allocated to rehabilitation programs or to the provision of other public goods or services to the population.

Legalization, however, in facilitating access to drugs, also brings costs to society, among which we can mention the occurrence of negative externalities, net losses and a likely increase in consumption.

Negative externalities concern the moral impact on people who are outraged by seeing, or even just by knowing the existence of drug use and health problems.

With regard to net losses, these refer to hours of work lost as a result of death or drug addiction, costs to health services for treatment of users or traffic accidents caused by drug users, and destruction or depreciation property resulting from a criminal action.

Legalization, however, tends to cause a reduction in the price of drugs, due to i. lower risk of production and sale, ii. greater efficiency, due to automation and more intensive use of technology and iii. Scale economy. Estimates vary from 75% (Van Ours, 2012) to 90% (Caulkins et al, 2012).

Lowering the price reduces the cost of consumption to users, which could reduce the occurrence of property crimes motivated to finance such consumption. But it will surely lead to an increase in consumption, reinforced by: greater accessibility and greater availability of information, besides removing the illegality status of the product (Jacobi and Sovinski, 2016).

Hall and Weir (2015), analyzing the consequences of legalization for recreational purposes in four US states, believe that the increase in consumption tends to be modest due to the limitation of the number of licenses and social disapproval stemming from six decades of prohibition. Moreover, in the specific case of the United States, the conflict between the current ban at the federal level and state laws may discourage consumption.

3. BRIEF DESCRIPTION OF THE RECENT DRUG POLICY IN URUGUAY

Since 1974 (Law n. 14,294), cannabis use has been decriminalized. Marijuana is the fourth drug in the order of preference of Uruguayans, after alcohol, tobacco and psychotropic drugs. Pressed marijuana arrives predominantly from Paraguay through small planes that land into clandestine runways. Uruguay, however, is not a relevant consumer hub (even for its lack of "scale"), nor a significant traffic flow.

The first manifestations of civil society in favor of legalization appear from May 2005. When Uruguay took office as a member of the UN Narcotics Commission, it took a critical stance on the "war on drugs". Since then, this is the position that has guided the country's performance in international forums, as evidenced by a profusion of documents available on the website of the National Drug Board (http://www.infodrogas.gub.uy/) of that country.

Thus, in May 2010 a bill was introduced allowing the domestic cultivation of marijuana. In the same year a committee of deputies was created to discuss drug consumption (Comisión Especial de Adicciones) and a second bill which foreseen for domestic consumption (8 plants or 25g), planting for scientific research and industrial use of hemp was presented in July 2011.

To force parliament to discuss the issue, on 08/08/12 the Executive sent a bill containing a single article for the state to take control and regulation of the production, storage, import and distribution of marijuana and its derivatives. The government estimated the revenues of this market at US$ 30 million per year. Since then, there has been a major national debate on the issue, which came to an end on 12/20/13, when Law n. 19,172 was passed by tight majority in the Senate (16 votes to 13).

In accordance with the provisions of Decree of May 6, 2014, which regulated Law n. 19,172 are permitted, subject to licensing, planting and cultivation, storage and distribution of psychoactive cannabis, including domestic cultivation, cultivation and consumption in cannabis clubs and sale in pharmacies.

With regard to domestic cultivation, up to six plants (up to 480 grams per year) are allowed per residence for Uruguayans or permanent residents in the Country. An individual cannot have more than one domestic crop and must avoid access by children, teenagers or third parties. Cannabis clubs may have 15 to 45 members, adults, Uruguayan or permanent residents in the country, cultivate up to 99 plants (up to 480 grams per year per member) and have only one seat where cannabis planting, harvesting and consumption occurs.

The sale for personal consumption will occur only in authorized pharmacies, directly to the consumer (again: adult, capable, Uruguayan or permanent residents in the country, who will need to prove residence). Thus, foreign consumption is restricted, as is drug tourism, since marijuana would need to be purchased by a Uruguayan who, every time he did so, would reduce his total quota of 480 grams per year.

This is an interesting feature, since it makes it difficult for consumers from the Rio Grande do Sul border buy Uruguayan marijuana, making Brazil an adequate group of control in the empirical strategy.

The consumer will have to choose a sole source of supply (club only, pharmacy only or personal planting) and places of consumption are restricted (eg no smoking in schools, hospitals or closed public places, as well as in workplace). In addition, any advertisement, by any means, is prohibited.

The national policy on marijuana falls within the purview of the National Drug Board, assisted by the IRCCA - Cannabis Regulation and Control Institute. This is the body responsible for granting permits for planting, harvesting, industrializing and distributing marijuana through authorized pharmacies, and prohibiting commercialization with unauthorized third parties. IRCCA is also responsible for quality control and the destination of production surplus.

IRCCA also has the authority to set and impose taxes as well as price controls (World Drug Report, 2016). However, unlike the US states that have legalized marijuana use for recreational purposes, the law still does not establish taxation for consumption, as well as explicitly exempting the alienation of agricultural goods destined for the marijuana production chain.

Law 19,172 is still being regulated: decrees were issued in December 2014 and February 2015. And marijuana began to be sold in pharmacies only in July 2017. This implies that noticeable effects will surge perhaps only five years after the promulgation of the Law.

IRCCA data referring to the 1st. term 2016 show 5,446 individuals registered as self-cultivators and 27 consumption clubs throughout the country, which means an average rate of 1.5 self-cultivators / thousand inhabitants.

A very recurring idea in the testimonies of institutional actors (advocacy, judges, prosecutors and police) involved with the issue of regulation is that nothing has yet changed in the country. The main conclusions of the Uruguayan policy monitoring and evaluation report, prepared by IPEA at the beginning of 2017, are that: a) it is still too early to perceive the impacts of the law, since its implementation process is under way; b) the relationship between drugs and crime is related to the cocaine base paste and not through marijuana, although there are cases of polydrug use; c) did not necessarily increase marijuana use, it became more public; d) more marijuana is consumed in Uruguay and less the pressed one coming from Paraguay, which can be considered a positive impact, with the decrease of the international traffic, however, e) decreased the age of beginning the consumption of marijuana.

The monitoring of the consumption of several drugs - licit and illicit - takes place through periodical surveys carried out by the National Drug Board, an organ linked to the Presidency of the Republic. To date, six household surveys (*Encuesta Nacional en Hogares sobre Consumo de Drogas*) have been carried out in 1994, 1998, 2001, 2006, 2011 and 2014. However, due to the methodology used and the sample coverage, only the last three are comparable (www.infodrogas.gub.uy), which is why only information of these is contained in table 1.

Table 1 Evolution of Drug Use in Uruguay - 2006/2014

Prevalence in the Last 30 Days

DRUG	2006	2011	2014
Alcohol	52.4	55.3	52.1
Cigarette	34.0	31.0	29.5
Depressant	-	-	8.9
Marijuana	3.5	4.9	6.5
Cocaine	0.8	0.9	0.6

Source: JND; Observatorio Uruguayo de Drogas (2016)
Note: - Not available

Observing the prevalence of consumption of the population from 15 to 65 years of age, it can be seen that marijuana is the only drug listed in the table that shows an increase (3 p.p.) over the period. Thus, in 2014, 6.5% of the age group surveyed made use of the substance in the month prior to the interview.

4. EMPIRICAL STRATEGY

Case studies are usually focused on specific events or interventions. For the most part, the objective is to detect the effects of these and their results, where researchers seek to position one or more units exposed to the intervention, or event, alongside those that were not.

It should be noted that the analysis of the effects of Uruguayan policy is essentially a problem of missing values, since it is not possible to observe the country simultaneously with and without the treatment (Statacorp, 2015). Thus, there is no possibility of obtaining a comparison after the application of Law 19,172, that is, the country cannot be observed in the condition of "treated" and "untreated", making necessary, then, the construction of counterfactual to replace missing values. To this end, the synthetic control method was adopted, which consists of creating a linear combination of the Brazilian states, which seeks to portray with the greatest possible reliability the situation in Uruguay.

Among the advantages of synthetic control, we can mention: i. performs better than (DID) estimator when there is a single unit treated (Conley and Taber, 2011); ii. the possibility of interaction of fixed effects over time provides a more adequate control of the effects not observed on the results; iii. Finally, the synthetic control method provides a more appropriate matching, since the Brazilian federative units, taken in isolation, are not as similar to Uruguay, as could be a linear combination of them (Abadie et al, 2010; Silveira neto et al, 2013). In this sense, for Athey and Imbens (2017, p. 9) synthetic control "is arguably the most important innovation in the policy evaluation literature in the last 15 years".

Denoting the value of the mains indicators of the evaluation (crime rate against property and homicide rate), of the location "i" with and without treatment, respectively $YitI$ and $YitN$, the method aims to obtain estimates for:

$$\tau it = YitI - YitN = Yit - YitN \text{ for } t > T0 \quad (1)$$

Where $YitI = Yit$, since this value is observable.

Estimates are then sought for $YitN$ based on data from the other J locations. It is worth noting an important characteristic of the synthetic control method: the interaction of the fixed effects of the states with temporal effects, which allows them to vary in time and contributes to the control of unobserved effects.

The technique then looks for among the vectors of weights W (Jx1), (w_1, w_2, ..., w_j), subject to the constraints that the weights must be positive and whose sum must equal the unit, such that $w_j \geq 0$ and $\Sigma_{j=1}^{J} w_j = 1$, a vector w * that involves the minimization of a distance measure (the Estimator Mean Square Error - MSPE) between the values of the variables of the locality that suffered the intervention - in this case, Uruguay -, and the same set of variables for the Brazilian states that did not undergo intervention in the same period, weighted by the vector of weights, $X0W$ (vector of weighted variables) in the preintervention period.

In summary, the strategy adopted here will seek to identify a linear combination of Brazilian states that presents the maximum approximation of the values of two indicators of violence (crime rate against property and homicide rate), with Uruguay, between 2008 and 2013, a period prior to the implementation of Uruguayan policy, using as covariate controls that affect the outcome of the selected indicators but are not affected by the aforementioned policy. Thus, an adequate counterfactual is obtained for comparison with the locality treated at the time of implementation of the policy.

Gender, age, level of education, GDP per capita, average salary, an indicator of income inequality, unemployment rate, demographic density and some items of per capita public expenditure will be used as covariates. The following dependency equations portray the relationships represented:

$TCP_{it} = \phi$ (men, young, lowsch, highsch, GDPpc, wmean, gini, ineq, unemp, dens, secexp, merexp) (2)

$THP_{it} = \gamma$ (men, young, lowsch, highsch, GDPpc, wmean, gini, ineq, unemp, dens, secexp, merexp) (3)

At where:

TCP_{it} = Rate of Crimes Against Property of the locality i in period t
THP_{it} = Homicide Rate of the locality i in period t
men = percentage of male population
young = percentage of the population aged 15-29 years
lowsch = percentage of the population with a few years of study
highsch = percentage of the population with many years of study
GDPpc = GDP per capita
wmean = nominal average wage
gini = Gini index
ineq = 20 + / 20- ratio
unemp = unemployment rate
dens = population density
secexp = public expenditure on defense and security per capita
merexp = sum of public expenditure on health, social assistance and social security per capita.

The rate of crimes against property for the Brazilian states represents the sum of robberies to financial institutions, theft of cargo and theft of vehicles[3], expressed in number of occurrences per hundred thousand inhabitants. In the Uruguayan case it represents the sum of robberies that occurred in the Country, also per hundred thousand inhabitants.

For both Brazilian states and Uruguay, the homicide rate represents the number of homicides divided by the population and expressed in a rate per hundred thousand inhabitants. The information comes from the Brazilian Yearbook of Public Security (Brazil) and the Statistical Yearbook (Uruguay) and is expressed in units commonly used in the literature.

[3] We chose these categories only because they presented the complete series (2008 to 2016), seeking to avoid the occurrence of an unbalanced panel. In order to avoid a bias in Brazilian data, the year 2010 (Census year) was excluded, since the main source of information - PNAD - is not available for census years and cannot be compared with census data.

As control variables (covariate), social, demographic, economic and public expenditure variables were selected, among the indicators usually employed in the Economics of Crime literature.

Among the demographic variables we use the percentage of men in the population of each locality, the percentage of young people between fifteen and twenty-nine years of age in the total population, besides of population density (number of inhabitants divided by the area of the locality). All data are from Statistical Yearbook (Uruguay) and PNAD (IBGE), except for the area of each state, given from the site of the Brazilian Institute of Geography and Statistics.

The educational level of the population was measured through two indicators: low schooling, representing the percentage of the population with up to four years of schooling, and high schooling, representing the percentage of the population with more than fifteen years of study. In the Uruguayan case, the first is restricted to individuals with up to 3 years of schooling while the second covers those aged over thirteen. Thus, due to the characteristics of the information, a better performance of Uruguay is predicted in this respect. The data come from the Statistical Yearbook (Uruguay) and PNAD (IBGE - Brazil).

Related to the economic variables, we employ the GDP per capita, the average salary of the formal employed, the Gini index, the 20 + / 20- ratio (which consists of dividing the proportion of the income maintained by the 20% most well-stocked by the proportion of the income earned by the 20% of lower income) and the unemployment rate. Brazilian information comes from IBGE (GDPpc), RAIS (wmean) and PNAD (ineq, unemp), while the source of Uruguayan information is the Statistical Yearbook. It is worth remembering that the Brazilian RAIS data is restricted to formal employment.

Finally, public expenditure on national defense and per capita security was used to obtain an idea of the amount made available individually for deterrence, in addition to the sum of public expenditure on health, assistance and social welfare as a proxy for the amount of welfare offered to each inhabitant. Both information comes from the website of the Brazilian National Treasury (FINBRA) and the Statistical Yearbook (Uruguay).

The monetary variables (GDPpc, wmean, secexp and merexp) are expressed in neperian logarithm of their nominal values. The Uruguayan information was previously converted into Reais (R$, the Brazilian currency) according to the exchange rate of December of each year, made available by the Central Bank of that Country.

In order to avoid that certain variables "dominate" the constitution of the synthetic control, the Pearson correlation coefficients and the Variance Inflation Factors (VIF) of the mentioned variables were calculated and we chose to remove those highly colinears: highsch, gini and wmean. After this procedure, all remaining variables have VIFs below ten.

The policy of interest was applied as of December 2013, when Law n. 19.172 passed, considering then the year 2014 as baseline and the years 2008 to 2013 as the pre-intervention period.

An important issue concerns the possible endogeneity present in the model. This could come from three sources: simultaneous causality, the effect of unobserved variables, and the selection of the contemplated regions.

With regard to reverse causality, the direction of the effect of the chosen variables seems clear in the sense of X to Y. One possible exception would be per capita security spending, which could be affected by the crime in the locality. Thus, the model was estimated excluding this variable as well. Regarding the effect of the unobserved variables, the adopted procedure, allowing the interaction of the fixed effects over time, allows the control of the effects not observed, restricting the endogeneity coming from this source. Finally, with regard to the selection of

treatment and control units, both were considered here as exogenous. As the control group includes all Brazilian states[4], here also does not seem to be a worrying source of endogeneity.

However, to ensure the internal validity of the results, some additional procedures will be performed, which will be detailed in the robustness section.

The choice of Uruguay is justified by the fact that it is the country that pioneered the implementation of a legalization policy for the entire marijuana production chain at the national level.

A final observation concerns the number of control units and pre-intervention time periods: according to Abadie et al (2010, p. 496-7), the synthetic control method produces non-biased results even when there is a single pre-intervention time available and does not demand a large number of comparison units.

5. RESULTS

This section provides the results of the data analysis. Initially, a descriptive analysis is presented. Then, we discuss the results obtained from the estimation of the synthetic control, as well as the procedures to check its robustness.

5.1. Descriptive Analysis

Table 2 presents the descriptive statistics of covariates and crime rates for the Brazilian states and for Uruguay from 2008 to 2016.

Table 2 Descriptive Analysis of Covariates and Criminality Indicators – UF´s Brazilian FU´s x Uruguai – 2008/2016

VARIÁVEL	Minimum		Maximum		Mean		Standard Error		E(x)/s	
	UF´s Brazil	Uruguay	UF´s Brazil	Uruguay	UF´s Brazil	Uruguay	UF´s Brazil	Uruguay	UF´s Brazil	Uruguay
THP	11.49	9.25	69.55	10.47	31.88	9.93	11.40	0.44	2.80	22.78
TCP	0.00	25.84	255.35	33.46	70.52	29.89	57.16	2.49	1.23	11.99
Men	46.81	48.01	52.49	48.37	49.01	48.29	1.05	0.12	46.85	389.44
Young	21.23	22.14	30.18	23.15	25.93	22.52	1.91	0.31	13.56	71.97
Low Schooling	14.32	6.06	41.85	8.40	28.00	7.01	5.90	0.97	4.74	7.24
High Schooling	2.25	16.00	19.42	25.13	6.46	20.16	2.86	3.86	2.26	5.22
GDPpc	5,389.15	18,855.63	68,959.83	51,369.94	18,500.58	32,742.28	11,340.56	12,268.16	1.63	2.67
Gini	0.421	0.385	0.624	0.445	0.519	0.412	0.037	0.026	14.07	16.03
20+/20- Ratio	9.03	2.77	31.40	3.28	16.02	2.97	3.87	0.16	4.14	18.22
Wmean	967.93	893.43	4,768.76	1,464.79	1,865.17	1,152.60	591.97	209.24	3.15	5.51
Unemp	3.0	6.3	15.5	8.0	7.4	7.0	2.34	0.69	3.14	10.10
SecExp	7.78	343.01	2,028.16	703.42	294.81	530.12	275.09	140.06	1.07	3.78
MerExp	34.56	2,221.29	9,237.13	5,021.62	926.02	3,495.32	1,035.26	1,058.84	0.89	3.30
Dens	1.97	18.77	506.06	19.81	71.02	19.41	108.87	0.39	0.65	50.42
Drug Supply	0.6	25.9	244.6	47.5	48.6	36.7	38.3	7.4	1.27	4.98

Sources: DATASUS, PNAD (IBGE), RAIS (MTE), FINBRA (STN) e Anuario Estadístico (Uruguay).

With the exception of a few variables (percentage of men and young people in the population and unemployment rate) one can perceive the existence of significant differences between the Brazilian states and Uruguay, starting with crime rates: while the Uruguayan homicide rate approaches of the level considered tolerated by the UN (10 per hundred thousand

[4] The construction of a control group composed of the other South American countries was not possible due to the unavailability of updated data and complete series of data, especially those related to crime and drug use / trafficking.

inhabitants), the Brazilian states average is close to 32 per hundred thousand inhabitants. The crime rate against property is also much lower in Uruguay, remembering that the proxy used in the Brazilian case is restricted to three types of robberies, which makes the difference even more whopping.

Among the demographic variables, one can point to the level of education: while more than 20% of Uruguayans have more than thirteen years of study, only 6.5% of Brazilians - in the states average - have more than fifteen full years of study. In spite of the fact that the Brazilian proxy is more restricted, the difference is eloquent here again.

Regarding the economic variables, Uruguay's per capita GDP is much higher (77% higher than the average of the Brazilian UF's), as well as the per capita expenditure with public security and meritorious goods (80% and 277%) significantly higher in Uruguay, although the average salary in Brazil is higher (R$ 1,865.00 x R$ 1,152.00)[5].

Also noteworthy is the terrible distribution of Brazilian income: while the 20+/20- ratio surpasses 16 in the country, in the neighboring nation it does not reach three. This means that in Uruguay the share of the appropriated income for the best-fortunate quintile is about three times greater than the appropriated portion by the lower-income quintile of the population.

A proxy for the supply of drugs in both countries was also built, based on the number of seizures (Brazil) and drug-related offenses (Uruguay), both expressed in rates per hundred thousand inhabitants. The information comes from the Brazilian Yearbook of Public Security and the Statistical Yearbook, respectively.

In spite of the fact that the information is potentially biased by productivity or police priority, it provides an important indicator for comparison, where it can be noted that the Brazilian rate is higher than the Uruguayan rate (48.6 x 36.7 per hundred thousand inhabitants).

Finally, it is worth mentioning the greater dispersion of data in the case of Brazil: the amplitude of the variables, shown in the first four columns, is always larger in the Brazilian context, while the relationship between the mean and the standard deviation of each variable, shown in penultimate and in the last columns of the table is superior in the Uruguayan context, denoting greater concentration of the data around the average in that country.

This brief analysis reflects the diversity among Brazilian U.F.'s and shows that few resemble Uruguay, making it difficult to apply matching techniques. This reinforces the pertinence of the application of the synthetic control, since this allows not only the use of the control unit components separately, but also of linear combinations of them, enabling the construction of a more adequate counterfactual.

5.2. Results and Discussion

The adoption of the synthetic control with nested variables produces a square root of the mean prediction error, respectively, of 2.7074 and 7.4550. For the homicide rate the synthetic control for Uruguay consists only of the state of Santa Catarina, while for the theft rate the synthetic control is composed of four states according to the following equations:

$$\text{Uruguay} = 1.00\ \text{SC} \tag{4}$$

$$\text{Uruguay} = 0.330\ \text{AP} + 0.036\ \text{RR} + 0.087\ \text{RS} + 0.547\ \text{SC} \tag{5}$$

[5] It should be remembered that income refers to workers with a formal contract (in addition to statutory ones), which overestimates the average for all Brazilian workers.

Table 3 shows the similarities and discrepancies between the covariates for Uruguay and their synthetic controls.

In the case of the synthetic control for the homicide rate, portrayed in the second column of the table, with the exception of the logarithms of GDP per capita and expenditures with meritorious goods, the percentage of men and young people aged 15-29 in the total population, there is considerable discrepancy in the other indicators. Thus, for example, while the population density in Uruguay was 19.47 inhabitants per km2, its counterfactual was 68.73 in the pre-intervention period. Nevertheless, with respect to the dependent variable, the homicide rate of the synthetic control is very close to the Uruguayan rate.

Table 3 Covariates - Uruguay x Synthetic Control
Homicide Rate and Robbery Rate

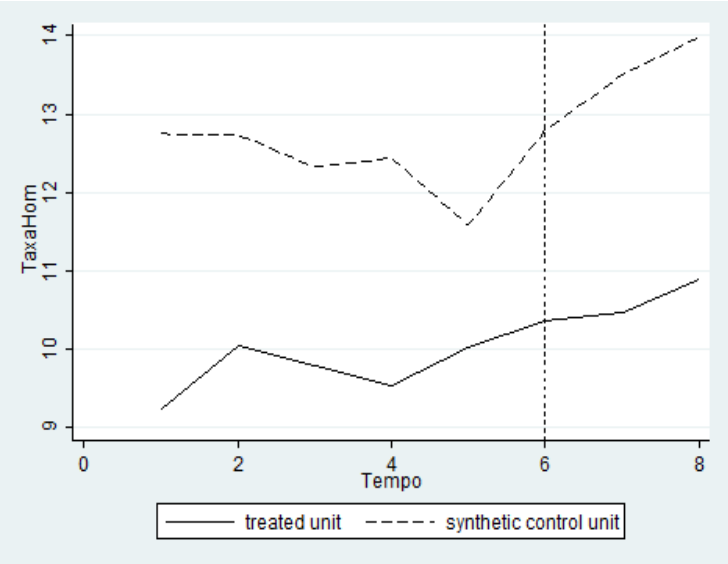
VARIABLE	TREATED	CONTROL TXHOM	CONTROL TXPROP
LnGDPpc	10.39	10.20	9.96
Men	48.30	49.21	49.41
Young	22.52	23.98	25.45
Low Schooling	7.01	24.93	23.48
20/20 Ratio	2.95	10.08	12.35
Unemp	7.11	4.32	7.12
Dens	19.47	68.73	42.78
Drug Supply	36.76	69.37	53.88
LnMerExp	8.20	6.70	6.80

Source: Authors estimates in Stata 12.0

Regarding the robbery rate, there is a greater similarity between the synthetic control and the unit treated, despite a significant discrepancy still remaining in relation to schooling and income distribution. Thus, while the 20+/ 20- Uruguayan ratio was, on average, 2.95 in the pre-intervention period, in the synthetic control this variable was four times higher (12.35). Nevertheless, the robbery rate of both is relatively similar until the year 2013, when this variable takes a jump in the synthetic control, as shown in figure 2b.

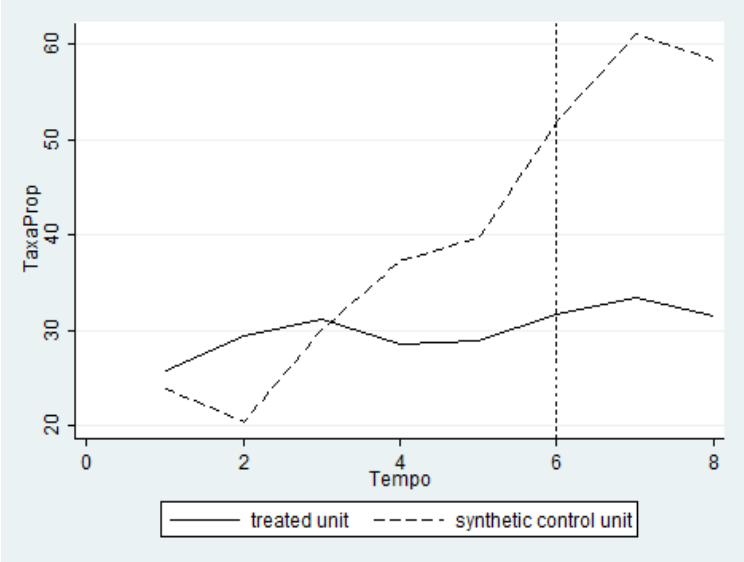
Graph 2a shows the homicide rate performance for the treated and control units. Note that Uruguayan regulation does not produce a break in the moderate increase tendency presented by the variable in that country, but it is able to positively differentiate its performance over that of the synthetic control which shows a more pronounced increase after 2013 and also after the intervention.

Regarding the robbery rate, the situation is different: a moderate increase persists in Uruguay, with a drop in 2016, while in synthetic control there is an explosion in the rate between 2009 and 2015, also falling in 2016.



Source: Elaborated by the Author

Graph 2 a Homicide Rate Uruguay x Sinthetic Control – 2008-2015



Source: Elaborated by the Author

Graph 2 b Robbery Rate Uruguay x Sinthetic Control – 2008-2015

Thus, despite the short time elapsed since marijuana legalization, as well as the fact that some aspects of this process are still being implemented - for example, sales in pharmacies began only in July 2017 - the first results seem to indicate that i. There was no significant change in crime trends previously observed in Uruguay; ii. Even so, a more exacerbated growth in homicide rates may have been avoided, and iii. In the case of theft, a more stable behavior was obtained, as suggested by the comparison with the performance of its counterfactual.

In this sense, our results are in line with the perception of Uruguayan institutional actors (advocacy, judges, prosecutors and police) according that nothing has changed in that country (IPEA, 2017), as well as with the findings of authors who point out as a characteristic of marijuana legalization processes the delay for the manifestation of significant changes due to the slow implementation (Van Ours, 2012; Vidal, 2016; Hall and Weir, 2015; Vasconcelos Jr., 2015; Dragone et al, 2017).

5.3. Robustness Analysis

The validity of the results found is, however, based on two hypotheses: i. the policy implemented in the treated unit did not affect the control units and ii. Brazilian states did not present palpable changes in terms of efficiency in the fight against crime. The violation of these hypotheses compromises the "purity" of the counterfactual and the magnitude of the estimated effect.

Thus, in this section three procedures will be performed to verify the robustness of the results found in the previous section. Initially, the state of Rio Grande do Sul, the only Brazilian border to Uruguay, where six twin cities (Aceguá, Barra do Quaraí, Chuí, Jaguarão, Quaraí and Santana do Livramento) exist on the border with that country, will be withdrawn from the control group, to ensure that it was not affected by Uruguayan policy.

Second, Brazilian states that have made significant changes to their crime-fighting policies in the period analyzed will be withdrawn from the donor pool, too.

Finally, a placebo will be performed in the year of implementation of the intervention, aiming to verify if the perspective of approval of Uruguayan legislation induced some previous change of behavior in that country. With the withdrawal of Rio Grande do Sul from the donor pool, the square root of the mean prediction error remains the same in the case of the homicide rate (2.7074), but increases in the case of robbery rate, from 7.4550 to 8.5795. The synthetic control for the Uruguayan homicide rate continues to be the state of Santa Catarina, while for the robbery rate the synthetic control is composed according to equation (6), where there is a distributed weight among the states of Amapá, Rio de Janeiro and Santa Catarina.

$$\text{Uruguay} = 0.282\ AP + 0.032\ RJ + 0.686\ SC \qquad (6)$$

Table 4 shows the similarities and discrepancies between the covariates for Uruguay and their synthetic controls for homicides and robberies.

Table 4: Covariates - Uruguay x Synthetic Control
Homicide Rate and Robbery Rate (without RS)

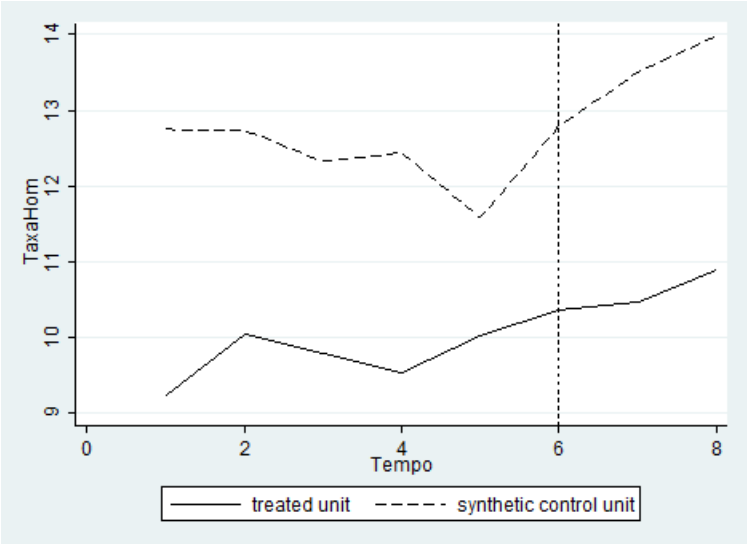
VARIABLE	TREATED	CONTROL TXHOM	CONTROL TXPROP
LnGDPpc	10.39	10.20	10.02
Men	48.30	49.21	49.34
Young	22.52	23.98	25.18
Low Schooling	7.01	24.93	23.86
20/20 Ratio	2.95	10.08	11.78
Unemp	7.11	4.32	6.65
Dens	19.47	68.73	60.50
Drug Supply	36.76	69.37	56.90
LnMerExp	8.20	6.70	6.82

Source: Authors estimates in Stata 12.0

In the case of the synthetic control for the homicide rate (SC) there is a great deal of similarity to the unit treated in terms of GDP per capita, expenditure on meritorious goods, percentage of men and young people, but there is a significant discrepancy in the other indicators. Thus, while in Uruguay the proxy for drug supply indicates a rate of 36.7 per hundred thousand inhabitants, in Santa Catarina it is 69.4. Nevertheless, the counterfactual homicide rate is close to the Uruguayan rate.

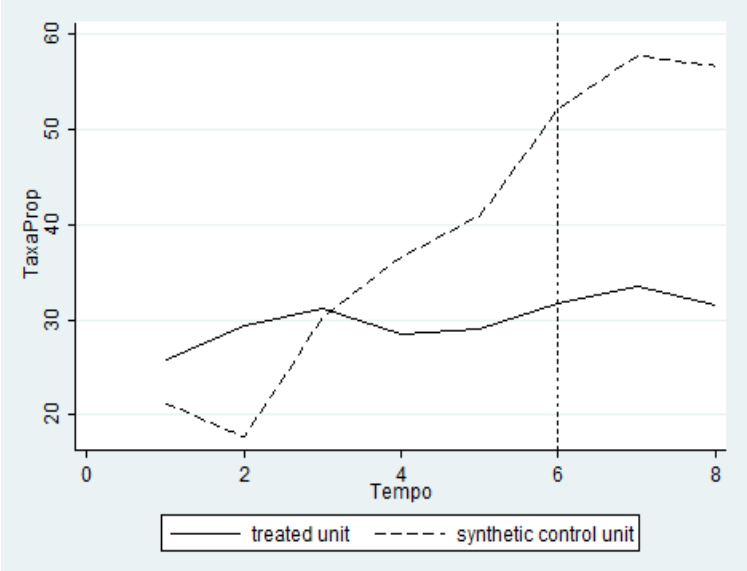
The synthetic control for the theft rate, portrayed in the last column of the table, in relation to the previous counterfactual (table 3), shows greater similarity with the unit treated in six variables, but it worsens in terms of discrepancy with respect to demographic density and drug supply, just to name a few. Thus, while the percentage of Uruguayans with low schooling was on average 7% in the pre-intervention period, in the synthetic control this variable corresponded to more than 25%.

Graph 3a presents the performance of the homicide rate for the treated and control units. Note that the Uruguayan regulation does not produce a break in the moderate increase tendency presented by the variable in that country, but is able to positively differentiate its performance in relation to that of the synthetic control that shows a more pronounced increase from 2013, as already shown in the graph 2a.



Source: Elaborated by the Author

Graph 3 a Homicide Rate Uruguay x Sinthetic Control – 2008-2015 (RS out)



Source: Elaborated by the Author

Graph 3 b Robbery Rate Uruguay x Sinthetic Control – 2008-2015 (RS out)

With respect to the robbery rate, a moderate increase persists in Uruguay, with a fall in 2016, however, in the synthetic control, there has been an increase in the rate since 2009, with a new jump in 2013 and a decrease in 2016, showing worse performance in the unit treated in the post-intervention period.

These patterns show that in fact there may have been some spreading of the effects of Uruguayan politics to the neighboring state (RS): when it is withdrawn from the donor pool, the composition of the synthetic control changes, although its performance reinforces the results of the initial model.

However several Brazilian states adopted policy measures to combat crime that had impact in the period 2008-2016, which may bias the behavior of synthetic control, making any comparison questionable.

Among these, we can mention São Paulo which implemented technological innovations, greater integration among the police, besides a significant increase in the seizure of weapons and the incarceration rate (Cerqueira, 2010; Hartz, 2010); Ceará, where there is a program to combat organized crime (Xavier, 2017), Espírito Santo, where the Plan to Combat Violence was adopted (Pereira and Grassi, 2012), Pernambuco, through the Pact for Life Program (Silveira Neto et al, 2013) and Rio de Janeiro with the implementation of the Integrated Areas of Public Safety and Peacekeeping Police Units (UPP's) (Pereira and Grassi, 2012).

Thus, the previously described procedures were performed again, this time removing the mentioned five states for the construction of a more "pure" synthetic control.

In the case of the homicide rate, this procedure raises the square root of the mean prevision error from 2.7074 to 7.7852, as might be expected given the lower availability of information for the construction of the counterfactual, but in the case of the robbery rate, this square root falls from 8.7494 to 7.2134.

For the homicide rate, the synthetic control for Uruguay now consists of the states of Amapá and Santa Catarina, with significant weight for the second, while in the case of the robbery rate the synthetic control is composed of the states of Roraima and Santa Catarina, where there is also predominance of the second, according to equations (7) and (8).

$$\text{Uruguay} = 0.275\ \text{AP} + 0.725\ \text{SC} \quad (7)$$

$$\text{Uruguay} = 0.240\ \text{RR} + 0.760\ \text{SC} \quad (8)$$

Table 5 shows the similarities and discrepancies between the covariates for Uruguay and their synthetic controls portrayed in the previous equations.

In the case of synthetic control for the homicide rate there is a great deal of similarity to most variables, but there is a significant discrepancy mainly in terms of schooling, income distribution, demographic density and drug supply. Thus, while in Uruguay only 7% of the population have low levels of schooling, in synthetic control this is the situation of 24% of the inhabitants. Synthetic control for theft rate reproduces the characteristics of synthetic control for homicides.

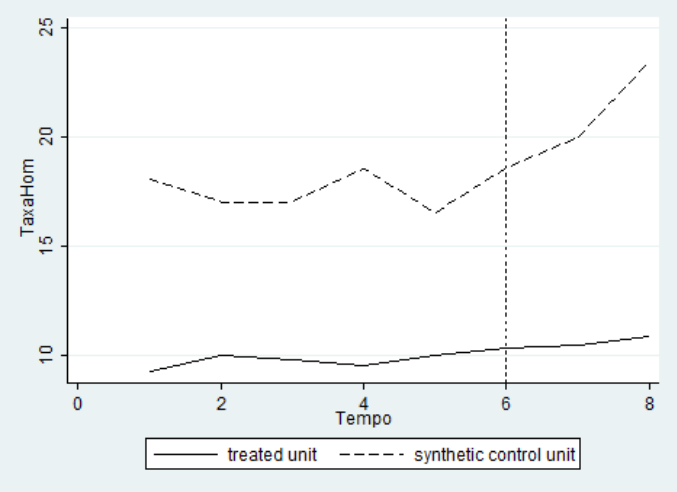
Table 5 Covariates - Uruguay x Synthetic Control
Homicide Rate and Robbery Rate (without states)

VARIABLE	TREATED	CONTROL TXHOM	CONTROL TXPROP
LnGDPpc	10.39	10.02	10.07
Men	48.30	49.40	49.51
Young	22.52	25.21	24.90
Low Schooling	7.01	24.01	24.05
20/20 Ratio	2.95	11.55	11.61
Unemp	7.11	6.44	5.24
Dens	19.47	51.22	52.74
Drug Supply	36.76	57.52	57.31
LnMerExp	8.20	6.81	6.77

Source: Authors estimates in Stata 12.0

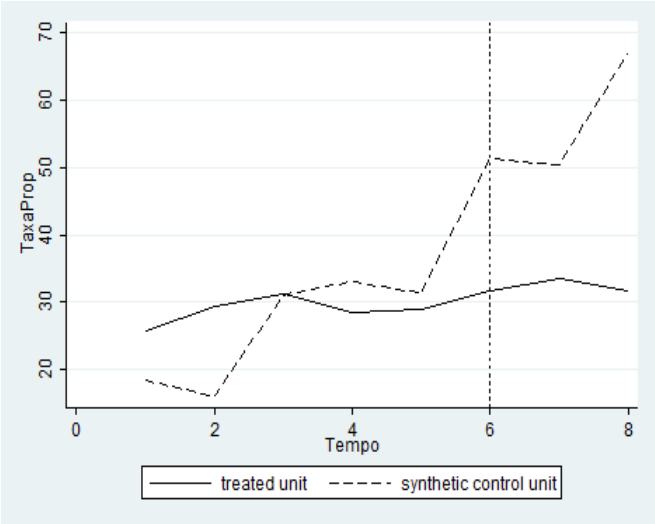
Graph 4a shows the homicide rate performance for the treated and control units. Uruguayan regulation does not produce a break in the moderate increase tendency presented by the variable in that country, but it shows superior performance in relation to that of the synthetic control, which presents an expressive increase in this modality of crime, reinforcing previous results.

With regard to the robbery rate, the withdrawal of the Brazilian states that took actions of policies to combat crime causes a rise in the rate of theft of synthetic control, contrary to what was seen in the previous graphs, but as expected, given the withdrawal of the UF's more proactive in fighting crime. In 2016, the robbery rate per hundred thousand inhabitants of the synthetic control is more than twice the Uruguayan rate.



Source: Elaborated by the Author

Graph 4 a Homicide Rate Uruguay x Sinthetic Control – 2008-2015 (UF´s out)



Source: Elaborated by the Author

Graph 4 b Robbery Rate Uruguay x Sinthetic Control – 2008-2015 (UF´s out)

To sum up, when we discard the units of the Brazilian Federation that implemented significant changes in policies to fight crime, we can see that Uruguay's marijuana legalization policy was able to generate positive results by provoking a more moderate increase in the homicide rate and fall in the rate of robbery in relation to its control.

A third procedure to gauge the robustness of the results was to implement a placebo of the beginning year of Uruguayan regulation. Thus, synthetic control for homicide and robbery rates was again carried out assuming that Uruguay had passed its legislation in 2013 (t-1), 2012 (t-2), and finally 2011 (t-3). In both cases, despite slight changes in the composition of the synthetic control, no significant change in previous results is observed, showing that they are robust to the change in the year of implementation of the policy.

6. CONCLUDING REMARKS

The objective of this study was to analyze the short term impacts of the Uruguayan policy of regulating marijuana production and consumption on the homicides and robberies of that country, contributing to the literature in presenting the first results of a unique situation in the world, the case of Uruguay.

For this, the study made use of the synthetic control methodology, using the Brazilian states as a control group. The results show that there was no significant change in crime trends previously observed in Uruguay, but a more exacerbated increase in homicide and robbery rates may have been avoided, especially in the latter, which shows a reduction in the unit treated against an expressive growth in synthetic control.

In order to assess the robustness of these results and to ensure their internal validity, three procedures were adopted: i. the state of Rio Grande do Sul was withdrawn from the control group because it was bordered by Uruguay, in order to ensure that the control group was not affected by Uruguayan policy; ii) the units of the Brazilian Federation that have made significant changes in their policies to combat crime in the analyzed period were excluded from the donor pool; and iii. a placebo of the year of implementation of the intervention was performed.

These procedures seem to confirm that, despite the fact that there has been no trend decline in the crime modalities examined, it may have prevented a more exacerbated increase in

the homicide rate in the unit treated, which is in line with the results found by several authors who analyzed the marijuana legalization process in US states. In addition, Uruguay presents a reduction in the robbery rate, while its synthetic control shows a significant increase in this type of crime.

This paper presents some limitations: first, given the specificity of the Uruguayan case, the results found here cannot be extrapolated to other situations; Second, given the impossibility of constituting a control group with the other South American countries, the Brazilian states were used but they are not exactly similar to the unit treated. Thus, finding ways of refining synthetic control, as well as analyzing the policy impacts on drug use and trafficking in Uruguay, seem to indicate fruitful paths for future studies.

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