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Recreational marijuana effect in labour market outcomes: Evidence from Uruguay

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Victoria, January 2020

1 Introduction

Recreational marijuana usage has been introduced in plenty of countries' debates as a possible progressive reform, now more than ever. On the one hand, people against recreational marijuana usage argue that the legalization would result in an increase in drug addiction, criminal behavior and consumption, and even in a low performance overall. On the other hand, supporters of this policy state that it helps to reduce crime by jeopardizing illegal marijuana producers and dealers. Also, by regulating the marijuana market, government and consumers can profit, respectively, by taxing this new market and by getting a lower price as a result of higher competition, in contrast to the monopoly held in the black market.

In 2013, Uruguay became the first Latin American country to allow recreational marijuana consumption, and it is still the only one in the continent. About 6 years after its approval, we want to focus on the impact it had on the labour market, more precisely on the unemployment rate. To do this, we will employ a synthetic control to identify the effect of this policy.

In the last few years, marijuana was legalized for recreational use in Uruguay, Canada and in many states of the US. The social and economic implications of such policies have been a major concern for policymakers and researchers. However, there is evidence that suggests positive effects of cannabis on multiple outcomes. For instance, Dragone et al. (2019) provide evidence of crime rates drop after marijuana was legalized in the US. They do this by exploiting the 2-years lag during which cannabis was legal in the state of Washington but not in the adjacent state of Oregon, even though both states had a ballot at the same time, were the first one approved the proposal by a slim margin and the second one did not, also by little. They also found an increase in marijuana consumption and a decrease on the usage of other drugs and alcohol. Even more, Dills et al. (2017) found that liberalization of marijuana in the US had no impact on youth drug use and youth criminal behavior, which are the most criticized outcomes by those against recreational marijuana.

Marijuana consumers have been anecdotally linked to low work performance, and the literature provides some mixed results on labour market outcomes. On the one hand, DeSimone (2002) analyzes the relation between the usage of illegal drugs and the effects on employment. By instrumenting consumption with the average price of drugs, he finds that the use of each drug substantially reduces the likelihood of employment. In a further analysis, Sabia and Nguyen (2018) seek the effect of medical marijuana laws in employment and wages. They exploit the different timing of medical marijuana laws in US states and, with a difference-in-difference approach, they find that these laws only moderately depress wages in young men. On the other hand, using individual data from Amsterdam, Van Ours (2006) has found no effect of cannabis or cocaine use on employment status. Nevertheless, Statistics Canada indicates that by August 2019 there were about 9200 people working in the cannabis sector in this country, a regulated industry since 2018. However, the

latter is only a partial equilibrium result, since it ignores the indirect effect of this policy on other markets, including labour market. Furthermore, such policies regulate a new market, and therefore it could be taxed, as Becker (2014) proposes as one of many advantages of legalization.

During José Mujica's Presidency (2010-2015) in Uruguay, two major bills were passed. First, in October 2012 an abortion law in the first 12 weeks of pregnancy was signed, after a failed attempt in 2008. Later on, in December 2013 the consumption and sale of marijuana was legalized, but it had to wait for regulations. During 2014, consumers were able to sign as home growers or club growers, and in 2017 marijuana was sold in 16 pharmacies in the country. However, consumer had to register in order to legally acquire marijuana, simply by filling a form at a post office, being over 18 years old and having an Uruguayan citizenship.

Because consumers were able to grow marijuana plants at home, identification within the country becomes quite difficult, due to endogeneity in the consumption and the potential spill-over effects. Therefore, in order to address this issue, we will rely on a synthetic control method and World Bank data to build a counterfactual for unemployment rate in Uruguay. First developed by Abadie and Gardeazabal (2003), synthetic control has been broadly used for identification when there is only one treated country. For instance, Billmeier and Nannicini (2013) use a synthetic with cross-country data to seek the effects of the liberalization of economies on real GDP growth. Also, within the marijuana literature, Hansen et al. (2018) test for a causal effect of marijuana legalization on traffic fatalities in Colorado and Washington with a synthetic control approach using records on fatal traffic accidents from 2000 to 2016. Interestingly, even though accidents increased after this policy, the synthetic suggests this would have also happened without recreational marijuana.

This study contributes to the literature in two ways. First, it is one of the first to address unemployment rate in an entire country. In contrast to Canada's industry, cannabis in Uruguay does not directly create many jobs. Therefore, we will study unemployment on a more general equilibrium approach. Second, to the best of our knowledge it is one of the first to study the effects in Uruguay, because literature has focused mainly in the US. One final comment should be made, even though the relation between marijuana consumption and unemployment rate might not seem clear at first, we will do our best to indicate that this link is compatible with the data. More precisely, results suggest that the legalization of recreational marijuana in Uruguay increased the unemployment rate of males in about 2.2% percentage points and mostly on young males aged between 15 to 24, who are one of the main cannabis consumers in the country.

The rest of the text is organized as follows. In section 2 we overview marijuana and its legalization in Uruguay. In section 3 we analyze the labour market in Uruguay, and in section 4 we present the empirical methodology and the sample data, followed by the results in section 5. In section 6 we explain our possible mechanism, which seems compatible with the observed data. Finally, in section 7 we conclude.

2 Marijuana Overview

2.1 Cannabis Effects

In order to identify any marijuana related effect, a general understanding of the drug and its biological mechanism is needed. As Genetic Science Learning Center (2013) and the National Institute on Drug Abuse (NIDA, 2019) explain, in the daily functioning of the body, cannabinoid receptors are responsible of releasing inhibitory neurotransmitters, which, as its name suggests, inhibit dopamine from being released. Andamine is the native cannabinoid, and when activaved, cannabinoid receptors turn off the release of these inhibitory neurotransmitter, thus allowing dopamine to be released. Tetrahydrocannabinol (THC) is the main psychoactive chemical in marijuana and it can mimic andamine, binding of to cannabinoid receptors. That way, inhibition is turned off and dopamine is released and can participate into the synapse. However, unlike THC, andamine breaks down quickly in the body, which is why the effect of THC lasts longer.

As Genetic Science Learning Center (2013) also explains, andamine is known to be involved in removing unnecesary short term memories, slowing down movement and reaction speed and providing a relaxation or calm feeling. Therefore, it is no surprise that there is evidence that smoking marijuana caused a THC-dose-dependant decrease in performance accuracy and increase in reaction times (Böcker et al., 2010), inefficient working memory function (Bossong et al., 2012), a reduced dopamine synthesis capacity in dependent cannabis users (Bloomfield et al., 2014a) and even in the long term (Bloomfield et al., 2014b). Furthermore, this last study indicates that the reduction in dopamine synthesis capacity may underlie reduced reward sensitivity and amotivation.

Also, marijuana plants require a special treatment, because its cultivation results in a higher or lower amount of THC. According to `ProductionGrower.com`, marijuana plants require up to 18 hours of light in the vegetative phase and 12 hours in the flowering phase. A fan should be place in the room with the plants, in order to remove the hot air plants produce and ventilate them. Finally, in the best scenario, marijuana flowers can be harvested after 10 weeks and after curing for a week, they are ready to be consumed.

Additionally, marijuana is a growing market worldwide. According to the United Nations Office on Drugs and Crime (2019) in its World Drug Report, marijuana is the most widely used drug worldwide. About 164 to 219 million people aged 16 to 64 used cannabis at least once in 2017, and there is an upward trend in the last two decades. Also, it indicates that cannabis usage is more prevalent among men than women in countries like Nigeria, India and Uruguay, among others. Furthermore, regarding it costs, it points out that prices have decreased in Colorado and Washington after legalization, the average annual price of cannabis flower decreased from USD 14.05 per gram in 2014 to USD 5.34 in 2017.

2.2 Legalization in Uruguay

On 31 April 2013 Uruguay's lower House passed the bill to legalize and regulate the sales and consumption of marijuana in the country. Almost eight months later, the 20 of December of 2013 the Senate approved the bill, which was signed three days later as Law 19.172 by President Mujica.

This law established the creation of a national cannabis control agency or IRCCA (for "Instituto de Regulación y Control del Cannabis"), such that potential consumers must register there and select one of the three mutually excluding sources for the acquisition of recreational marijuana: home growing, forming cannabis clubs (or social clubs) and buying from pharmacies. In order to register, consumers must register by filling a form at a post office and waiting for an approval. This process has no cost and the only requirements are being an Uruguayan citizen (by blood or naturalized) and over 18 years old.

However, consumers had to wait almost a year for the law to be regulated. On 27 August 2017, the register for home growing was opened. As legislation established, Uruguayans are allowed to cultivate a maximum of 6 plants per household. Additionally, marijuana cannot exceed 10 grams per week or 40 grams per month, obtained through any of the three mechanisms. IRCCA's statistics indicate that by 1 October 2014 there were 601 registered domestic growers, a year later on 31 October 2015 there were 3100, another year later on 1 October 2016 this number grew to 5332 and finally the latest available data is that by June 2019 there were 7163 registered home growers, as can be seen in Table (1). Additionally, Table (1) displays the distribution of home growers, where it can be seen a concentration on the departments of Montevideo (which contains Uruguay's capital city Montevideo) and the adjacent department of Canelones. Furthermore, Maldonado department, which contains the touristic city of Punta del Este, has the highest consumers to over 18 population ratio.

Later on, on 30 October 2014, the register for the creation of social clubs or cannabis clubs opened. Regulation established that clubs had between 15 to 45 members and can cultivate up to 99 plants, where the 10 grams a week rule per member also applies. By January 2020, there were 4298 members in 145 clubs, which suggests that more clubs are being formed compared to the 3417 members in 123 clubs indicated in Table (1). Similar to the domestic cultivators group, club members are centered around Montevideo, Canelones and Maldonado, with a high peak on Maldonado with respect to over 18 population.

Finally, consumers had to wait much longer for pharmacies to sell cannabis. First, on May 2014 the government offered pharmacies to register for selling, and a call for tenders for marijuana cultivation was conducted on August 2014. However, due to bureaucracy and delays, two companies were selected for cultivation of up to 2 tons a year each on October 2015 and cultivation effectively began in February 2016. Finally, the register for pharmacy acquirers opened on May 2017 and very quickly became the most popular

Table 1: Consumers in regulated market by mechanism, based on department of registration at June 2019

Department	Population over 18	Pharmacy acquirers	Domestic cultivator	Club members	Total registered	Regulated every 1000 over 18
Maldonado	118.301	4.024	615	590	5.229	44,2
Flores	18.201	382	69	-	451	24,78
Montevideo	1.010.307	20.782	2.173	1.578	24.533	24,28
Treinta y Tres	34.042	615	75	-	690	20,27
Lavalleja	43.259	702	114	-	816	18,86
Canelones	375.379	5.003	1.148	570	6.721	17,9
Rocha	49.379	143	383	298	824	16,69
Paysandú	78.589	909	283	70	1.262	16,06
Salto	85.042	1.098	163	26	1.287	15,13
Durazno	39.766	484	105	-	589	14,81
Artigas	49.66	507	110	89	706	14,22
Colonia	91.199	314	537	108	959	10,52
San José	78.736	520	230	-	750	9,53
Tacuarembó	62.668	268	224	-	492	7,85
Río Negro	37.45	92	153	22	267	7,13
Florida	48.395	226	116	-	342	7,07
Soriano	58.536	167	241	-	408	6,97
Cerro Largo	58.897	131	190	39	360	6,11
Rivera	71.066	94	182	27	303	4,26
No register	-	26	52	-	78	-
TOTAL	**2.408.872**	**36.487**	**7.163**	**3.417**	**47.067**	**1,954**

Source: retrieved from IRCCA (2019)

of the three mechanisms. As Table (1) displays, by June 2019 there were about 36487 people registered for this method, which covers little more than three quarters of the entire regulated market.

However, when marijuana was sold for the first time on 19 July 2017 on 16 pharmacies, it was sold in a 5 grams dose with only up to 2% of THC content, a relative low percentage, at a price of 187.04 Uruguayan pesos (or USD 5.87). Later on, this content increased to 9%, which is a more commonly used concentration, and since 1 February 2020, 5 grams of flowers cost 265 Uruguayan pesos (USD 6.92). Potentially due to its relative low cost and simplified acquisition, this mechanism has the highest number or registered consumers and has a distribution similar to domestic cultivators and club members, as Table (1) displays. More importantly, IRCCA (2019) indicated that by June 2019, 88% of the registered acquirers effectively bought marijuana at a pharmacy at least once.

Then, even though consumers should register for acquisition, the regulated market does not cover the entire market. First, in its usual market report, IRCCA (2018) indicates that if every domestic cultivator and club members provide another two persons, and pharmacy acquirers only share it to another one, then regulated market can reach up to 54% of the demand. Therefore, regardless of the precise number, government acknowledges that individual consumption has a direct spill-over effect, because legal consumers will provide marijuana to illegal consumers, either by selling or sharing the product. After all, the 10 grams a week of 40 grams a month limitation is no real limitation. For reference, Ridgeway and Kilmer (2016)

find that an average marijuana cigarette contains between 0.30 and 0.35 grams of marijuana. Therefore, consumers can on average obtain about 30 marijuana cigarettes every week. Pardal et al. (2019) provide evidence of this, they find that social clubs are popular because their members are able to reduce production costs, involve into a social activity and even obtain a quantity that usually exceeds their personal needs, so members usually sell their surplus to non-members.

Additionally, even though consumers were legally able to acquire or cultivate marijuana only from 2014, we will refer to the treatment period as year 2013. This is because this policy was the main national debate during 2013, and it could have an effect before the effective legalization, due to some anticipation effect, as Abadie and Gardeazabal (2003) suggest. However, it is important to point out that legalization was not very popular at the time. Conducting three surveys in the country, Cruz et al. (2018) find that about 60.7% were against marijuana in 2014, where by 2017 (before the implementation of pharmacy sales) 54.1% remained opposed to this policy.

2.3 Marijuana Consumption in Uruguay

Regarding marijuana consumption in Uruguay, data from the Household's Drug Consumption National Survey (known in spanish as ENHCD) reveals the pre-treatment population and part of its evolution. First, by 2001 there were near 100.000 Uruguayans that had ever experienced with marijuana, where this number almost doubled by 2006. In contrast, about 259.000 consumed marijuana in the last 12 months prior to the survey in 2018, an almost twice as many people had tried it in their lifetime.

Second, as can be seen in Table (2), there is an upward trend in the consumption of marijuana in the last two decades, even before legalization was discussed. According to the last ENHCD (2019), about 25.500 people smoke marijuana daily in 2018, in contrast to 18.700 daily users in 2011, and half of them present signs of problematic use. Even more, about 19.5% of male consumers present these signs, in contrast to 10.3% of females, as a result of the higher consumption frequency among men. Additionally, Table (2) shows that men are more likely to consume marijuana than women, at every intensity. This indicates that there is a pre existent difference between male and female consumption.

Table 2: Trends in marijuana consumption

	General Population					**Male Population**				**Female Population**			
	2001	2006	2011	2014	2018	2006	2011	2014	2018	2006	2011	2014	2018
Ever in life	5.3	13.1	20	23.3	30.2	16.6	25.2	29.8	34.9	8.3	15.2	17.2	22.3
Last year	1.4	5.5	8.3	9.3	14.6	7.5	11.5	12.5	17.8	3	5.4	6.4	9.8
Last month	0.5	3.5	4.9	6.5	8.9	5	7	9.4	12.1	1.7	3.1	3.8	6.3

Source: Household's Drug Consumption National Survey

Then, if we examine the population that effectively consumed marijuana ever in life as shown in Table

(3), we note a difference in male and female behavior towards consumption. First, male consumption has consistently been smaller than female among people that have tried it only once, similar at a medium intensity level and higher at a weekly or daily frequency. Second, while male consumption on a weekly or daily frequency has increased in the last decade, females tend to smoke marijuana more sporadically or to experiment. This can be seen by noting a decreasing trend in female consumption in a weekly and daily frequency, potentially due to the increase in the occasional use. Therefore, men have not only been more likely to smoke marijuana, they also have a stronger usage of this drug.

Table 3: Consumption frequency among consumers, as a percentage of total consumers

	General Population				**Male Population**				**Female Population**			
	2006	2011	2014	2018	2006	2011	2014	2018	2006	2011	2014	2018
Once	10.8	8.7	8.6	13.7	7.8	5	6.5	8.1	17.3	15.8	12.5	22.2
Last year	36.5	29.9	32.5	34.3	37	30.5	28.2	32.9	35.4	28.8	40.5	36.5
Monthly	22.5	25.2	24.7	21.1	24.5	24.6	24	22.9	18.1	26.4	25.9	18.5
Weekly	19.1	21.1	21	20.9	19.1	21	23.3	23	19	21.2	16.7	17.7
Daily	11.2	14.6	13.2	9.9	11.6	18.1	18	13.1	10	7.8	4.4	5.2

Source: Household's Drug Consumption National Survey

Later on, we must examine the difference across the different age groups. Table (4) displays the available percentage of marijuana consumers in different age group. Clearly, there is a peak among 19 to 25 and 26 to 45 years old people: about half of Uruguayans in this age group by 2018 consumed marijuana at least once in their life and even around one of every five Uruguayans aged 19 to 25 has tried marijuana in the last month. Therefore, data suggest that young people are persistently more likely to consume marijuana than the elderly, which is no surprise.

Table 4: Trends in marijuana consumption, in age groups

	15 to 18 years		**19 to 25 years**		**26 to 35 years**		**36 to 45 years**		**46 to 55 years**		**56 to 65 years**	
	2014	2018	2014	2018	2014	2018	2014	2018	2014	2018	2014	2018
Ever in life	20.5	23.5	40	49.7	39.8	51.6	20.1	28.5	11.3	16.1	4.3	6.3
Last year	14.8	19.1	22.5	32.6	14.2	25.4	4.9	8	2.1	4	0.5	1.1
Last month	11.2	11.3	16.6	20.8	9.4	16.4	2.8	3.8	1.3	2.2	0.4	0.6

Source: Household's Drug Consumption National Survey

Overall, a legal marijuana market implied a significant drop in the cost of consuming marijuana. After all, its legal price is remarkably lower than in the US, for example, and there is also an important reduction in the subjective costs of acquisition. Therefore, an increase in consumption is expected although it behaves as anticipated by the previous trend.

Finally, we must analyze consumption in the regulated market. According to ENHCD (2019), by 2018 one of every three consumers obtained marijuana directly or indirectly through the legal market. Furthermore, according to IRCCA's (2018) usual report, in this legal market, males are the main consumers and represent 75.8% of domestic growers, 70.2% of pharmacy's acquirers and about 80.5% of members of growing clubs.

3 Labour Market in Uruguay

3.1 Unemployment and Labour Force

On the one hand, Uruguay is a small country with a steady population. As World Bank data shows, population in Uruguay surpassed the 3 million barrier in 1985 and has only increased half a million since then. Furthermore, between 2000 and 2018 population went from 3.319.736 to 3.449.299 or about 4% in almost two decades. On the other hand, labour force increased from 1.567.214 people in 2000 to 1.774.336 in 2018 or about 13% in two decades, which is significantly larger than the population increase during the same period.

Using World Bank data, as it will be explained in a following section, Figure (1) displays labour force participation rate in addition to male and female participation rates as a share of their respective labour force. For a visual purpose, participation rate in 2013 represents 100%. In this figure, an upward trend in female participation rate is displayed. However, female labour market in Uruguay suffered an important shift in October 2012, after abortion was legalized in the country during the first 12 weeks of pregnancy. Given that Uruguay's public health system covers the cost of the medical intervention, it is expected that more women are able to take a part in the labour market since abortion allows them to remain working or even join the labour force. In contrast, male participation rate was similar in 2000 and 2013 and experienced a decrease afterwards. As a result of this, the share of female work force to total labour force went from 43.13% in 2000 to 45.48% in 2019.

Figure 1: Labour force rates (2013 = 100%)

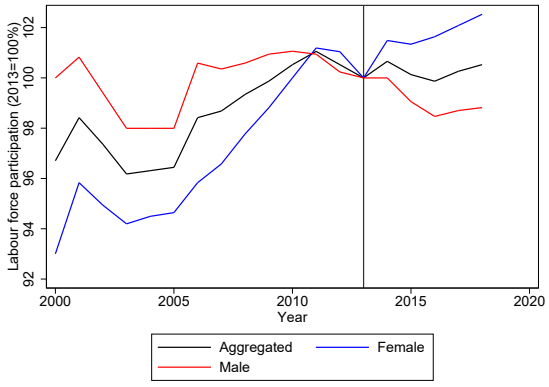
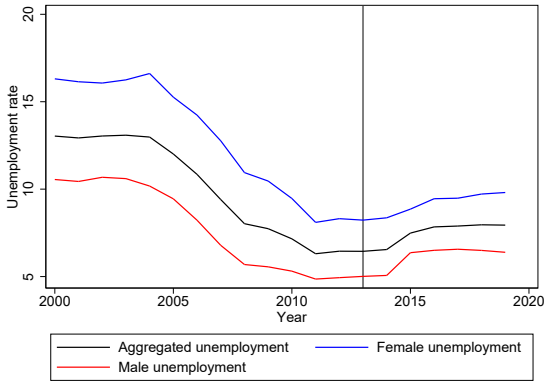


Figure 2: Unemployment rates in Uruguay



Additionally, Figure (2) displays the unemployment rate in Uruguay between 2000 and 2019, and we will refer to it as the aggregated unemployment rate. Also, this figure shows male and female unemployment rates for the same period. Even though labour force persistently increased since 2000, the unemployment

decreased from 2000 to 2013 and even in 2019 with respect to 2000. Also, female and male unemployment had a similar trend behavior but not at the same level, because women persistently had a larger unemployment rate. Overall, there are only two differences at first glance in the behaviour of these outcomes. First, even though 2004 was a turning point for unemployment, the fall was sharper for women. Second, male unemployment suffered a sudden sharp increase between 2014 and 2015, whereas women's increase was smoother. This results in a flat increase in its weighted average, the aggregated unemployment. Therefore, after seeing this data, we will distinguish the unemployment rate for male and females when estimating the synthetic control.

3.2 Wages in Uruguay

Even though synthetic control adjusts for unobservable confounding factors that vary with time, as it will be explained in the following section, in order to make the synthetic control more reliable, we want to see the evolution of real wage and minimum wage in Uruguay. Naturally, an increase in unemployment would be expected after a significant increase in minimum wage. However, authors like Card (1992), Card and Krueger (1993) and Dinkelman and Ranchhod (2012) provide evidence of situations in which rising the minimum wage had a small effect, if any, on the employment rate. In the case of Card and Krueger (1993), they make a natural experiment using the increase of minimum wage of New Jersey. They analyze the variation of employment in fast food restaurants and control them with Pennsylvania employment, where there was not an increase in their minimum wage. The main results of their research provides evidence that an increase in the minimum wage does not reduce employment. Therefore, an increase in minimum wage in Uruguay might not imply a larger unemployment rate. However, as this might be a controversial result, we will examine the minimum wage and a real wage index so we can clear the effect.

In Figure (3) we can see the variation of the minimum wage in Uruguay in the last 18 years. As we can see, after 2013 the change is almost constant around 10% and it might be due to inflation, which was about 8% every year during the same period. Also, after the large Uruguayan crisis of 2002, with a high inflation rate, minimum wage suffered an important increase in 2005 to recover its purchasing power.

Following Shapiro and Stiglitz's (1984) theory about unemployment, it's important to show Uruguay's real wage trend. Their theory states that, when considering effort, optimal wage has to be greater than the equilibrium wage, in order to increase the opportunity cost of being unemployed and so increase effort among workers. Therefore, companies will hire less workers due to a higher wage or cost and, as a result, they will increase effort of workers in comparison with the situation in equilibrium. However, this greater wage will also generate involuntary unemployment, because people willing to work for the optimal wage will

Figure 3: Change in minimum wage in Uruguay

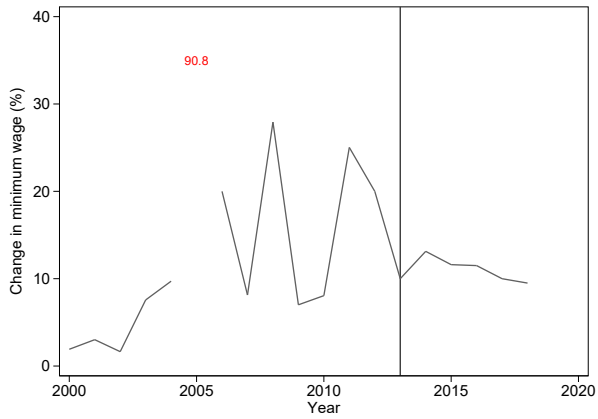
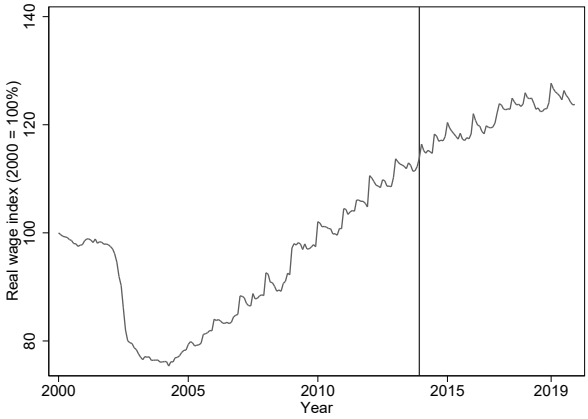


Figure 4: Real wage in Uruguay



Source: Data from Uruguay's National Statistics Institute (INE)

not be hired by companies.

Considering that marijuana can affect the reward system and make people less willing to work efficiently, it modifies the opportunity cost of working and making an effort. Therefore, the Shapiro-Stiglitz theory should be suitable in Uruguay, where companies might be doing so to control Uruguayans worker's effort. By consistently increasing wages, companies might ensure a higher effort level. Figure (4) displays the percentage change in the real wage index. As a result of the 2002 crisis, there was a huge fall in real wage of about 20% in that year, followed by a persistent increase to recover the previous level, which continued even after 2013. Hence, growth of real wage is in part to recover the purchase power and, after legalization of recreational marijuana, to increase effort levels among consumers. However, because real wage increased constantly after 2002, this rise cannot explain the sudden increase in unemployment rate after 2013.

4 Identification Strategy and Data

4.1 Synthetic Control Method

In order to measure the causal effect of marijuana legalization, we want to consider the difference between Uruguay's unemployment rate after the treatment and its counterfactual, that is, this outcome in the absence of the intervention. Given that Uruguay is the only treated country, identification is challenging. For instance, a simple before-and-after analysis will contain other effects than those induced by this law.

Therefore, we rely on a synthetic control method to estimate the effect of this policy. First proposed by Abadie and Gardeazabal (2003) and followed by Abadie et al. (2010), a synthetic control is a statistical method based on the idea that a fixed weight combination of different non-treated units in a pre-intervention

time period can resemble the treated unit before and after the treatment. Therefore, an artificial or synthetic unit that approximates Uruguay before the intervention can consistently estimate a non-treated Uruguay after marijuana legalization. Naturally, this method is more reliable with a larger time period and more non-treated units. Also, it is important that none of the donor pool units have been treated, otherwise the synthetic control will be biased. For this reason, we exclude Netherlands, United States and Canada due to their marijuana policies. However, interestingly when included, these countries have no positive weight.

Regarding the use of this method, a synthetic control is a widely used tool for identification in a situation where there is only one treated unit. Athey and Imbens (2017, p. 9) describe this method as "arguably the most important innovation in the policy evaluation literature in the last 15 years", and as Billmeier and Nannicini (2013) argue, a synthetic control allows the effect of unobservable confounding factors to vary with time, which distinguish it from a before-and-after estimator, for example. Therefore, this methodology is great for assessing the aggregated outcomes of countries, such as GDP, inflation, exports, etc.

Formally, for a time period $t \in \{1, ..., T\}$ and a unit $j \in \{1, ..., J+1\}$ let $Y_{j,t}$ be the unemployment rate for the country j in period t. For simplicity, we refer to Uruguay as unit 1 so that the donor pool or the non-treated units consist of the remaining J countries. Also, let $Y_{1,t}^N$ be the unemployment rate in Uruguay in the absence of the intervention after treatment year $T_0 = 2013$. Therefore, the desired effect to be estimated is the following:

$$\alpha_t = Y_{1t} - Y_{1t}^N \tag{1}$$

However, given the nature of the problem we observe only Y_{1t} after T_0, then we use a synthetic control to consistently estimate Y_{1t}^N. As suggested by Abadie and Gardeazabal (2003) and Abadie et al. (2010), we use a weighted combination of unemployment rates from the donor pool units. The corresponding weights $w = [w_2, ..., w_{J+1}]$ are non-negative and such that $\sum_{j=2}^{J+1} w_j = 1$. Ideally, weights should meet two conditions. First, the synthetic unit should perfectly reproduce the outcome prior to the intervention. Also, weights should not only fit the outcome, but the covariates of the synthetic unit should perfectly resemble the covariates of Uruguay. Therefore, weights for the synthetic control should meet the following conditions:

$$\sum_{j=2}^{J+1} w_j Y_{jt} = Y_{1t} \ \ \forall t \leq T_0 \tag{2}$$

$$\sum_{j=2}^{J+1} w_j Z_{jt} = Z_{1t} \ \ \forall t \leq T_0 \tag{3}$$

Where Z_{jt} denotes the vector of explanatory variables for country j in time period t. Clearly, equations

(2) and (3) hold exactly if (Y_{1t}, Z_{1t}) belongs to the convex hull denoted by the outcome and its predictors for all donor pool's units and all pre-treatment periods. However, in practice this is not the general case, but it is sufficient that conditions (2) and (3) hold approximately. Therefore, following Abadie and Gardeazabal (2003) and Abadie et al. (2010) we choose w^* as the vector that minimizes distance

$$(X_1 - X_0 w)' V (X_1 - X_0 w) \tag{4}$$

subject to the non-negative and sum-to-one conditions imposed on w. Here, X_1 stands for the $(K \times 1)$ matrix of K pre-treatment variables in Uruguay, X_0 is the $(K \times J)$ matrix of K pre-treatment variables for the J countries in the donor pool and V is a symmetric, positive semi-definite and normalized-to-one matrix that reflects the relative importance assigned to each variable prior to the intervention. Since w^* will depend on the choice of V, so will the synthetic estimates[1]. Therefore, as it is conventional in the literature, we will employ matrix V^* so that the mean square prediction error (MSPE) of the outcome variable is minimized in the pre-intervention period:

$$MSPE = \frac{1}{T_0} \sum_{t=1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{J+1} w_j^*(V) Y_{jt} \right)^2 \tag{5}$$

Then, the synthetic unemployment rate estimate for Uruguay $\forall t > T_0$ is defined as the following:

$$\hat{Y}_{1t}^N = \sum_{j=2}^{J+1} w_j^* Y_{jt} \tag{6}$$

Finally, the estimated effect $\hat{\alpha}_t$ results by substituting estimate from equation (5) into equation (1). As Abadie et al. (2010) show, $\hat{\alpha}_t$ is a consistent estimator of the effect of the policy.

4.2 Inference

As Abadie et al. (2015) suggest, statistical inference is difficult in this model due to the absence of randomization and the small-sample nature of the problem. However, inference can be done by conducting some placebo studies. Naturally, a large estimated effect $\hat{\alpha}_t$ is meaningless if we obtain similar results for countries where the policy was not implemented, or if there was already a large difference between Uruguay and the synthetic before the intervention.

Therefore, inference is done by removing Uruguay from the data and estimating a synthetic control for

[1]Some authors propose a cross-validation approach for the election of V. We will refrain from this perspective and select V that minimizes the MSPE of the outcome for the pre-intervention period. For further references, see Abadie et al. (2015).

every country in the donor pool. Then, difference $\hat{\alpha}_{jt}$ between the placebo unit j and its synthetic control during time period t is calculated. However, to acknowledge the pre-treatment lack of fit of the synthetic control, following Galiani and Quistorff (2017) we standardize the effect dividing it by the square root of the pre-treatment MSPE of placebo unit j ($RMSPE_j$) as described in Equation (5).

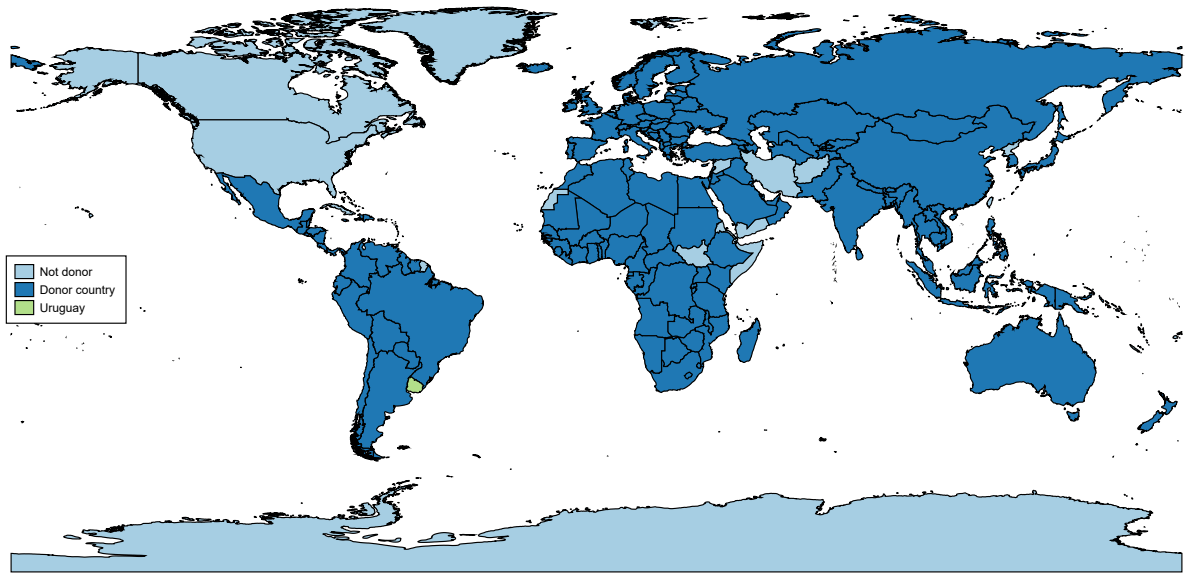
Then, inference is conducted by examining how large the standardize effect for Uruguay is relative to the distribution of the effects for countries that did not legalize marijuana. More precisely, for $t \geq T_0$ the two-sided p-value is then

$$\text{p-value}_t = \frac{1}{J} \sum_{j=2}^{J+1} \mathbf{1} \left(\frac{|\hat{\alpha}_{jt}|}{RMSPE_j} \geq \frac{|\hat{\alpha}_{1t}|}{RMSPE_1} \right) \tag{7}$$

4.3 Data

For this study, we obtained unemployment data from the World Bank and the International Labour Organization[2] (ILO), in addition to macroeconomic control variables such as GDP per capita (measured in 2010 constant prices), inflation, foreign direct investment, exports and imports. Given that the synthetic control method does not allow missing values for any time period, we kept data for countries with complete reported annual unemployment rates between 2000 and 2019. Then, we removed United States, Canada and Netherlands to avoid endogeneity due to their legal marijuana policies. Therefore, the donor pool consists of 164 countries ($J = 164$) as shown in dark blue in Figure (5).

Figure 5: Donor pool map



[2]ILO's statistics were retrieved from `www.gapminder.org`

5 Results

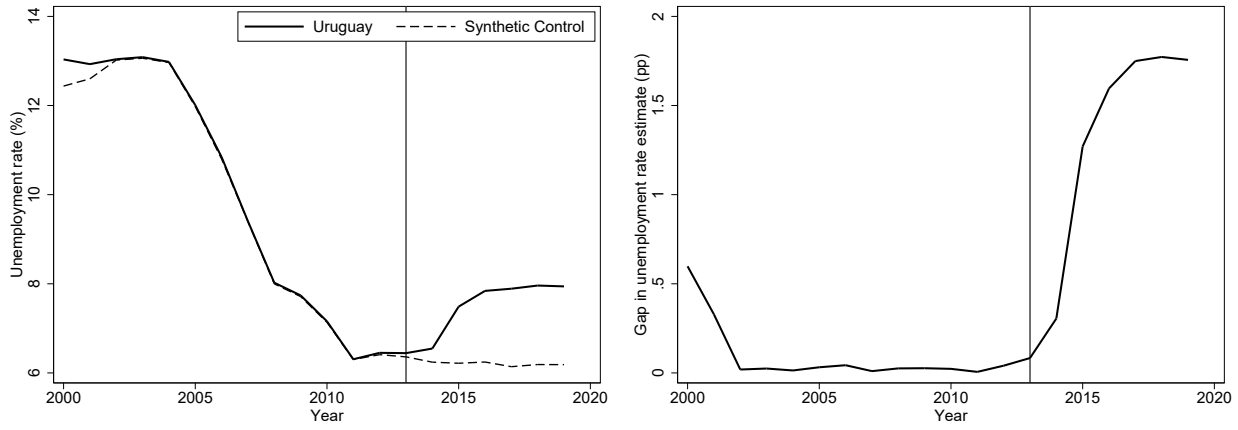
Motivated by the relation between GDP and unemployment as Okun's Law suggests, and by noting evidence of the relationship between GDP and unemployment in Uruguay in a large time period (Merlo and Porras-Arena, 2019), we estimate a synthetic control for Uruguay using GDP per capita as a main predictor for every year prior to the intervention, in addition to lagged unemployment rates. However, the results are robust (remain unchanged) to the inclusion of other relevant macroeconomic variables such as inflation, foreign direct investment, exports and imports.

5.1 Impact on Unemployment

5.1.1 Impact of Aggregated Unemployment

As can be seen in Panel (a) of Figure (6), the synthetic control perfectly fits the outcome prior to the intervention except for the 2000-2002 period. Thereby, it indicates that unemployment would have remained almost constant after 2011 with a slightly decreasing trend. Also, it is important to point out that only 15 countries have a positive weight, as can be seen in the first column of Table (5). Even though the list of countries might seem counter intuitive at first glance with only 4 countries of Latin America, these countries resemble Uruguay in the pre intervention period. Noteworthy, Uruguay is a country who saw neither a decrease in employment nor in GDP in the 2008 crisis. Therefore, part of the weights might be given to countries with a similar behavior in that adverse moment.

Figure 6: Aggregated unemployment rate



(a) Unemployment rate (%)

(b) Gap between Uruguay and synthetic Uruguay (pp)

Also, results in Figure (6) suggest that there was not a constant effect after marijuana legalization. As can be seen the first column in Table (6), the anticipation effect in 2013 was little or nil and small in 2014,

the first year where marijuana was regulated. Afterwards, this effect grew and since 2017 there is a steady difference of about 1.75 percentage points in unemployment rate. However, this gap in the aggregated outcome is not statistically significant for any time period after the intervention, as can be seen in the first column of Table (6).

Table 5: Weights for donor countries in different specifications

	Aggregated unemployment		Male unemployment		Female unemployment	
N	**Country**	**Weight**	**Country**	**Weight**	**Country**	**Weight**
1	Angola	0.343	Turkmenistan	0.175	Angola	0.355
2	Panama	0.173	Angola	0.158	Mali	0.210
3	Lebanon	0.125	Panama	0.128	Israel	0.110
4	Oman	0.084	Niger	0.127	Macao	0.087
5	Macao	0.081	Poland	0.105	Samoa	0.062
6	Germany	0.037	Lebanon	0.074	Paraguay	0.043
7	Samoa	0.033	Macao	0.064	Bosnia-Herzegovina	0.037
8	Mali	0.029	Germany	0.046	Germany	0.028
9	Serbia	0.028	Suriname	0.033	Jordan	0.026
10	Dominican Republic	0.024	Egypt	0.031	Peru	0.024
11	Montenegro	0.016	Sudan	0.024	Panama	0.014
12	Palestine	0.007	Switzerland	0.016	Serbia	0.002
13	Egypt	0.006	Oman	0.013		
14	Brazil	0.006	Brazil	0.006		
15	El Salvador	0.006				
	Total:	**1.00**		**1.00**		**1.00**

Due to the heterogeneous consumption of marijuana described previously, it is expected that the treatment had a different effect on male and female workers. Therefore, we estimate a synthetic control for the unemployment rate distinguishing by sex. After all, given that the aggregated unemployment is a weighted average of male and female behavior, it could happen that one of these outcomes is statistically significant but not the other, hence damaging the significance of this average.

Table 6: Estimated gap between Uruguay and synthetic control on different specifications

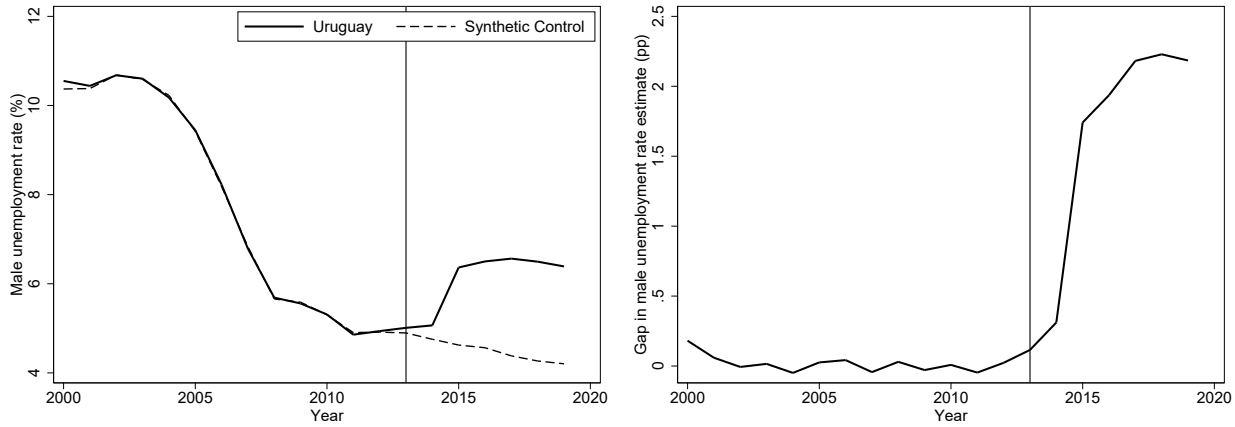
	Unemployment		Male unemployment		Female unemployment	
Year	**Gap**	**p-value***	**Gap**	**p-value***	**Gap**	**p-value***
2013	0.0834	0.7622	0.1151	0.3476	0.1800	0.8232
2014	0.3051	0.4756	0.3112	0.0915	0.5702	0.5976
2015	1.2704	0.1341	1.7411	0.0122	0.6923	0.5915
2016	1.5959	0.1159	1.9364	0.0122	0.7162	0.5976
2017	1.7495	0.1098	2.1817	0.0122	1.2815	0.4878
2018	1.7725	0.1037	2.2288	0.0122	1.4551	0.4512
2019	1.7562	0.1098	2.1845	0.0122	1.4815	0.4634

*Standarized p-values are displayed

5.1.2 Impact on Male Unemployment Rate

For males, Panel (a) of Figure (7) displays the estimate for Uruguay's male unemployment rate. This synthetic fits almost perfectly the outcome in the pre-intervention period and, in contrast to the previous synthetic, it fits even in the 2000-2002 period. Also, results suggest that if marijuana was not legalized, then the unemployment would have continued its decreasing trend. Naturally, this is in case that the underlying identification assumption applies and that no other major event affects unemployment, apart from this marijuana law.

Figure 7: Male unemployment rate



(a) Male unemployment rate (%)

(b) Gap between Uruguay and synthetic Uruguay (pp)

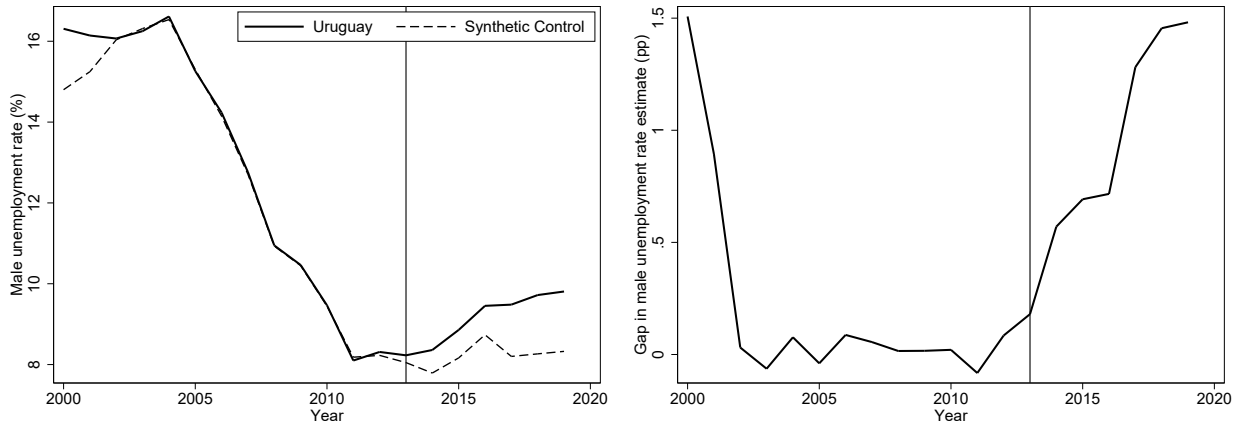
Similar to the aggregated outcome, we note a small or nil anticipation effect in 2013. However, we see a very sharp increase of the estimated effect in year 2015, which is the first complete year where all Uruguayans were able to acquire marijuana. In contrast to aggregated unemployment, the effect is statistically significant in 2014 at a 10% level and at a 5% level afterwards, as can be seen in Table (6). Also, from 2017 to 2019 the estimated effect is an increase around 2.2% percentage points in unemployment rate for male labour force.

By comparing this synthetic with the one for aggregated unemployment, there is a large list of 8 countries (Angola, Panama, Lebanon, Oman, Macao, Germany, Egypt and Brazil) with positive weights in both aggregated and male unemployment, which represent 85.5% of the weights for the former and 52% for the latter. Therefore, there are similarities between these outcomes, although it is clear that the aggregated unemployment also contains information from other dimensions, mainly due to female's behavior, that male unemployment is not able to capture.

5.1.3 Impact on Female Unemployment Rate

Then, similar to the male case, we estimate a synthetic control for the female unemployment rate. Panel (a) of Figure (8) shows the estimated rate in the absense of marijuana legalization, where it can be seen that the synthetic control fits the pre-intervention rate in the 2002-2012 period. Similar to the aggregated unemployment and in opposition to male's rate, female synthetic does not fit unemployment in the 2000-2002 period, which is compatible with our idea that the lack of fit in aggregated unemployment's synthetic is due to female's noise or bad adjustment. In line with this idea, the estimated effect of the policy in years 2018 and 2019 is similar to the gap in year 2000, hence suggesting that this difference is more likely to be by chance than causal.

Figure 8: Female unemployment rate



(a) Female unemployment rate (%)

(b) Gap between Uruguay and synthetic Uruguay (pp)

Also, there is a list of 7 countries (Angola, Panama, Macao, Germany, Samoa, Mali and Serbia) with positive weights for aggregated and female unemployment which represent 72.4% and 75.8% of the weights, respectively. It is clear that the aggregated unemployment contains part of the female effect and even reinforces the validity of the selection of these countries, because the behavior of unemployment is similar to Uruguay both for females and overall.

Moreover, an important comment should be made about the identification strategy conducted here. Before marijuana was legalized, Uruguay passed a major and controversial abortion law in October 2012. Therefore, effects from marijuana and abortion policies cannot be distinguished. After all, both policies could potentially affect labour market for women and even in opposite directions. In this case, we found no significant effect in female unemployment, but if there were any, this could not be attributed entirely to marijuana due to this abortion policy.

5.2 Inference

In order to conduct inference, we estimated the placebo studies as denoted previously, and displayed in Figure (9). By doing this, we can see if the effect in Uruguay is large relative to the distribution of the placebo effects. In panels (a), (c) and (e) of Figure (9) we can see the difference in percentage points of the respective unemployment rates. In all three specifications, Uruguay fits the pre-treatment data more accurately than the placebos, which implies a gap around zero in that period.

However, the situation is completely different after the treatment, where Uruguay's gap is closer to zero in comparison with the placebos. Therefore, to encompass both effects, we see the ratio of post-marijuana legalization RMSPE to pre-intervention RMSPE, displayed on panels (b), (d) and (f) of Figure (9). In the case of aggregated unemployment, Uruguay's ratio is larger than average in the distribution, although not big enough to be significantly different from the mean.

Additionally, data displayed is consistent with our idea that aggregated unemployment effect was not statistical significant because male of female's effects were not significant. As can be seen in Figure (9), female's ratio is right in the center of the distribution, while male's ratio is not. Therefore, it is clear that its weighted average (or the aggregated unemployment effect) will be smaller as a result of female's small effect or low goodness of fit.

5.3 Comparing Synthetic Controls

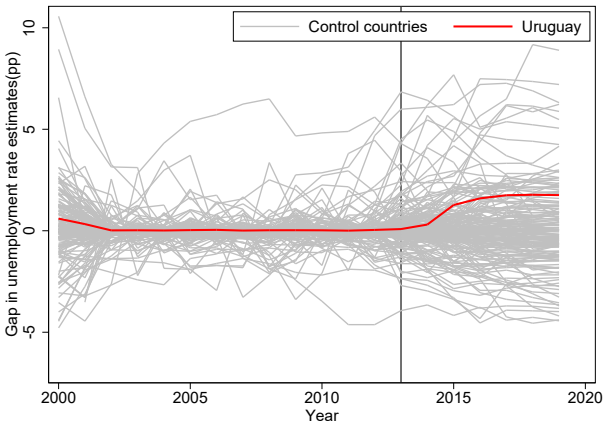
Regarding the quality of the synthetic control, the list of donor countries with positive weight might seem counter intuitive at first glance, as indicated previously. However, we must note that the countries with positive weight are not drastically modified when we change the outcome. In fact, in two out of three specifications Angola is the donor with the largest weight (34.3% for aggregated, 15.8% for male and 35.5% for female unemployment) and is the second most important in the remaining specification.

Moreover, as denoted previously, there is a large list of 8 countries with positive weight in aggregated and male unemployment and a similar list of 7 countries for aggregated and female unemployment. Therefore, there are 4 countries (Angola, Panama, Macao and Germany) with positive weight in all three specifications, which represents 63.4% for aggregated, 39.6% for male and 48.4% for female unemployment. Hence, weights are not casually chosen to simply resemble data, since a significant part of the variation can be attributed in all three outcomes to only 4 countries out of 164.

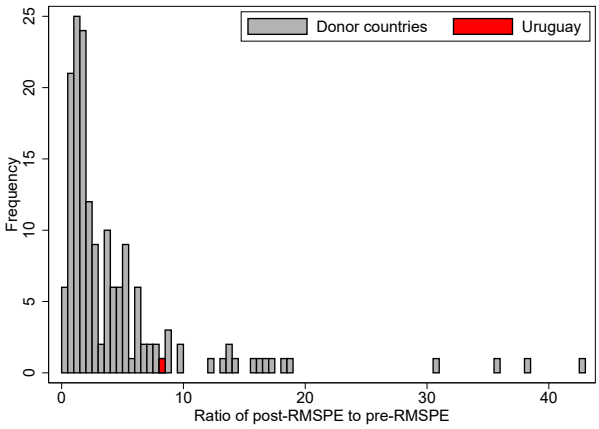
Additionally, it is important to note that the effect was neither immediate nor constant. In fact, this is compatible with the non-simultaneous regulation for marijuana acquisition. After all, only after August and October 2014, people were able to register as home growers or in clubs, respectively, and marijuana was sold

Figure 9: Placebo studies

A: Aggregated unemployment

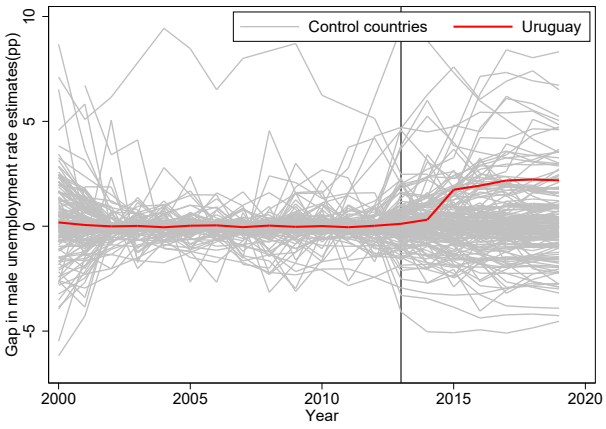


(a) Gap in unemployment estimates (pp)

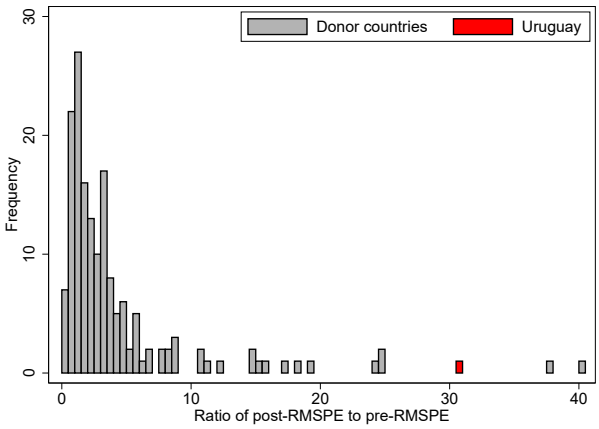


(b) Ratio of post-RMSPE to pre-RMSPE

B: Male unemployment

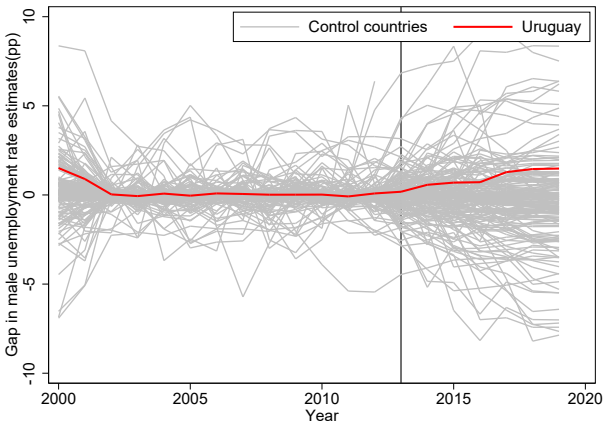


(c) Gap in unemployment estimates (pp)

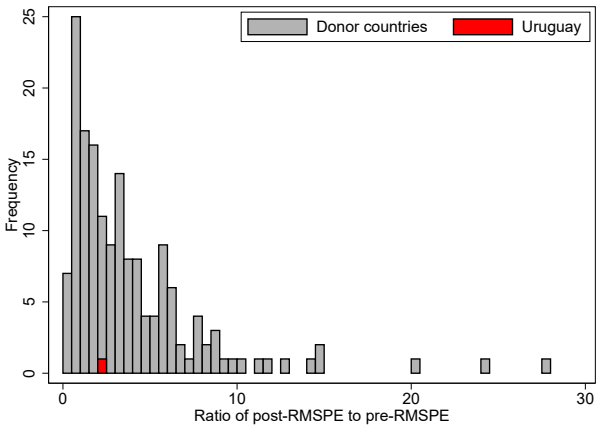


(d) Ratio of post-RMSPE to pre-RMSPE

C: Female unemployment



(e) Gap in unemployment estimates (pp)



(f) Ratio of post-RMSPE to pre-RMSPE

in pharmacies in July 2017 for the first time. Therefore, results suggest there was no anticipation effect in 2013, only a small increase in 2014 due to regulation delays and a sharp effect afterwards.

6 Potential Mechanisms

The link between job market and marijuana consumption may seem unclear at first glance. However, marijuana consumers anecdotally have been related to low productivity or bad job performance. We will propose two potential mechanisms by which recreational marijuana could explain the increase in unemployment.

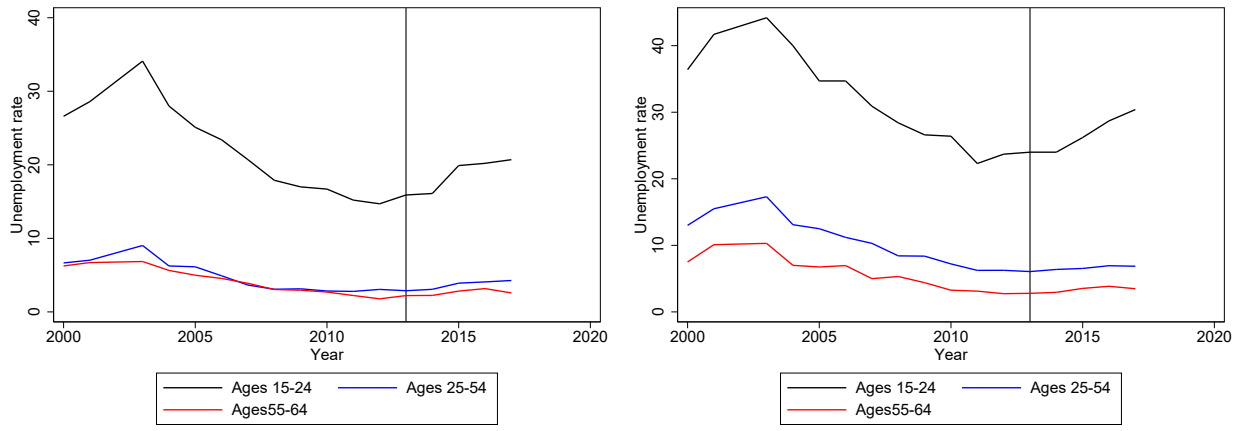
First, a potential mechanism is related to the lack of motivation and disinterest in marijuana consumers. As mentioned previously, marijuana consumption affects dopamine synthesis capacity, which relates to the reward system (Bloomfield et al., 2014b,a). Therefore, its deficiency underlies reduced reward sensitivity and motivation. Consequently, we propose this as a potential mechanism: since consumers are less motivated, when they face an adverse situation, they might not effort and thus result in neither studying nor looking for a job. After all, for young consumers, this is the time period in life where it is more likely to face this type of adverse situation, due to the insertion to labour market or in higher education.

Therefore, like the distinction between male and female population done before, we will separate them in age groups, mainly because marijuana consumption peaks when consumers are around 25 years old. Thus, using ILO data, in Figure (10) we display male and female unemployment rates divided by age groups of between 15 to 24, 25 to 54 and 55 to 64 years old. Naturally, labour force is centered mostly in the first and second group, whereas marijuana consumption is centered in the first one. As a result of this, we note that male and female aged between 15 to 24 are the only affected after 2013, which is the age group most likely to face the adverse situations described previously.

Second, as denoted before, the legalization of marijuana increased the consumption, mostly, in young males. This increase in cannabis usage might make consumers relax their short term expectations about their professional future. That is, they might simply decide to seize the present and maximize their short term utility. As a result, they may neither look for a job nor study. However, this has later consequences in labour market, because when this subgroup finally decides to get in the job market, they will have some trouble finding one. This is mainly because they are in disadvantage relative to their non-smoking peers, since they do not have any degree or work experience and are around the same age. In this case, companies decide not to hire them ergo they become unemployed.

Moreover, it is necessary, in agreement with our potential mechanisms, that the effect on unemployment is not immediate, because both mechanisms have a medium-term effect. This is shown in Figure (7), where it is possible to see that the effect found in the synthetic starts after the legalization of recreational marijuana.

Figure 10: Unemployment rates by age groups



(a) Male unemployment rates by age groups

(b) Male unemployment rates by age groups

Also, it is relevant to show the difference between the two stages that we mentioned previously. On a first moment, they were not considered unemployed because they were not looking for an employment. Later on, they become unemployed when looking for a job and not being hired. Therefore, we would expect first a decrease in labour participation rate, because they are not looking for a job, followed by an increase in this rate, when they decide to work. As can be seen in Figure (1), this is exactly what happens to men's labour participation rate, which decreases in 2016 in comparison to 2013, and then starts recovering back to its previous level, which is evidence in favor of this last proposed mechanism.

7 Conclusion

Recreational marijuana usage has been introduced in plenty of countries' debates as a possible progressive reform, now more than ever. In 2013, Uruguay became the first country in Latin America to allow recreational marijuana consumption. Its consumers have been anecdotally linked to low work performance and productivity, and literature has focused on the individual effect of cannabis consumption on unemployment likelihood. In this work, we assess the effect that this policy had on Uruguayan unemployment rate, in contrast to the local or partial effect on individuals described previously.

Even though marijuana consumption and unemployment might seem unrelated at first glance, we did our best to indicate that this relationship is compatible with the data. Therefore, we analyze the minimum wage growth in Uruguay, the real wage evolution in the period and control for GDP per capita, inflation, foreign direct investment, exports and imports. Nevertheless, we understand that there might be more mechanisms compatible with the data that we have not found. However, by estimating a synthetic control,

our results suggest that marijuana had a small but not significant increase in unemployment rate. When distinguishing between men and women, the effect on males becomes statistically significant at a 5%, but not on women. More precisely, it seems to show that the legalization of recreational marijuana has increased the unemployment in young male population, who are one of the main cannabis consumers in Uruguay.

In future researches, the unemployment in the long run could be studied. Even though there is already a significant maturation time of 6 years, it would be interesting to see if this effect persists or if generations learn from previous experiences. Additionally, effects on education could be assessed, in order to see if marijuana affects labour market through education.

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