Beyond legalization: Access and use of (non-)drug-trafficking marijuana

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Abstract

Recreational marijuana legalization aims to reduce the drug trafficking market's presence and societal costs. Post-legalization, a third of Uruguayan marijuana users still buy from drug dealers. I assess the effect of legalization on the black market's presence. For this, I estimate a novel demand model in a post-legalized environment that includes access selection/limitations, alternative choices regarding the source (legal or drug trafficking), and individual-level prices. I use these estimates to identify tools that steer the demand to the legal market. Counterfactuals show that a 10% price reduction increases legal marijuana use by 9%, but primarily driven by new users. Reducing access to the drug trafficking market decreases the use of both legal and illegal marijuana, emphasizing access's role in demand. In contrast, widespread legal marijuana access leads to a 17% increase in legal use, with half coming from the drug trafficking market. Understanding consumer substitutions between (il)legal options is crucial for policies targeting black market reduction.

Keywords: marijuana demand, marijuana legalization, illicit markets, limited access.
JEL Classifications: D12, H80, I18, K49,

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1 Introduction

Marijuana ranks as the most prevalent illicit substance worldwide, with roughly 5% of the population aged 15 to 64 using it in the past year (UNODC, 2021) and a global market value of around USD 40 billion. Several countries have embraced or are deliberating the legalization of recreational marijuana use. Policymakers predominantly advocate legalization as a tool to diminish the presence of the drug trafficking market. In this regard, Uruguay became the first country to legalize recreational marijuana in 2013, with the primary objective of curbing the drug trafficking market and the high level of violence associated with it (Queirolo et al., 2019). Uruguay's framework permits its citizens to procure recreational marijuana through licensed pharmacies, social cannabis clubs, or home cultivation, all under the regulatory purview of the Institute of Regulation and Control of Cannabis (IRCCA). Notably, despite this policy shift, around a third of users in the country still resort to the drug trafficking market, obtaining marijuana directly from drug dealers. Understanding this demand behavior and proposing different tools to steer the demand is crucial, especially in countries where the black market's violence and the associated social costs are very high.

This paper analyzes the effect of legalization on the drug trafficking market's presence, while incorporating the role of access. I estimate how consumers substitute between legal and illegal sources, when the legal market is more accessible or the drug trafficking market is more challenging to access. Understanding the proper tools in order to steer the demand is critical for public policy, especially in a market where promoting consumption is not desired. For this, I propose a novel demand model where an individual, conditional on her level of access, chooses between drug trafficking marijuana, legal marijuana, or no marijuana use. Modeling access is motivated by the evidence that not every individual knows how to obtain marijuana from dealers and/or that not every individual can obtain marijuana from legal sources due to geographical constraints. Moreover, individuals who know how to obtain illegal drugs may be more interested in using marijuana or vice versa. My demand model also allows for this potential correlation between access and use.

To empirically identify the substitution patterns, I mainly use the VII National Survey on Drug Use in the General Population 2018 (NSDUGP), performed by the Uruguayan Observatory of Drugs, after all the legal marijuana sources opened. It contains individual-

level socio-demographics and drug use information. The sample represents 1.8 million individuals of the Uruguayan population (with a total population of 3.4 million). In particular, this survey allows me to observe the main sources of marijuana that individuals use and the accessibility to the drug trafficking market. Past-12-month marijuana users (around 14 percent of the sample) also reported where they mainly obtained the marijuana: from drug dealers, pharmacies, social clubs, self-cultivation, resellers, etc. The data indicate that around a third of users bought marijuana (in)directly from *dealers* in the drug trafficking market. In addition, every surveyed individual reported information regarding accessibility to drug dealers. That allows me to define that 65 percent of the sample has access to the drug trafficking market. Lastly, with department-level data,[1] I can observe the size of the legal market. I use this information to define access, at the individual level, to the legal and drug trafficking market.

I build a model based on random utility maximization in which an individual selects whether to have access to the drug trafficking market or not. This selection depends on individual-level socio-demographics and department-level crime information. Moreover, access to legal marijuana is exogenous for the individual and depends on the individual's geographic location. With this, choice sets are generated for every individual, given that not everybody is able to obtain illegal marijuana and/or lives in a location where legal marijuana is an available option. Considering the individual's choice set, she chooses one of the following as differentiated products: drug trafficking marijuana (if available), legal marijuana (if available), or no use of marijuana (always available), according to her indirect utility. These choices will depend on individual-level socio-demographics, prices, and department-level information. Importantly, I allow for a correlation between the individual's access selection and the marijuana use decision through the (un)observable individual's attributes. Individuals who know how to get an illegal drug (i.e. through a known drug dealer) may be more interested or comfortable regarding using (any) marijuana. At the same time, individuals who enjoy using marijuana may be interested in accessing the drug trafficking market to obtain an additional (and illegal) marijuana option or other illegal drugs. My model captures the potential correlation of these two decisions.

Regarding results, I find that incorporating access selection in the model is crucial for accurately capturing substitution patterns. I find a stronger negative price effect with

[1] Uruguay is divided into 19 *departments*, which are (political) subdivisions of the territory.

respect to a model that does not consider access selection or restrictions. Moreover, given individual-level data, I estimate how different (individual) socio-demographics and market-level attributes affect access selection and the marijuana alternatives choice. Furthermore, I find a positive correlation between the selection of having access to illegal drugs and the marijuana use decision. The correlation is not only through the observed individual socioeconomic attributes but also through the unobservables. In particular, the model shows a positive correlation between the unobservables of 0.4. This implies, for example, that reducing the likelihood of accessing the drug trafficking market would result in a reduction in the use of any marijuana. In other words, if illegal drugs are harder to get, individuals will be less interested in using marijuana, whether it comes from the drug trafficking market or not.

The government could apply policies to enhance (decrease) accessibility to the legal (drug trafficking market) market. I performed counterfactuals that show different tools to steer the demand toward the legal market. First, given limited access to legal sources, I show that a legal price reduction may be inefficient for attracting drug trafficking users. Cross-price elasticities are low, resulting in this policy primarily creating new users while only marginally reducing the drug trafficking market. In particular, a 10 percent price reduction for legal marijuana leads to a 9 percent increase in its use, primarily due to new users. Second, decreasing access to the drug trafficking market reduces the overall marijuana use rate (not only the drug trafficking marijuana use rate). This suggests that when individuals lose contact with illegal drugs or dealers, they will be less likely to use marijuana, regardless of the source. This is driven by the estimated positive correlation between the (un)observables that affect the access selection to drug trafficking marijuana and the marijuana use decision. In the third counterfactual, in contrast, making legal marijuana accessible to all individuals results in a 17 percent increase in its use, with half of this increase involving drug trafficking users transitioning to the legal alternative. Limited legal access creates a situation where individuals who would easily switch to a legal option do not, as it is unavailable to them. This analysis provides valuable insights into how substitution occurs in a market where promoting substance use is not desirable. The novel ingredients of my demand model, combined with the comprehensive data, generate proper estimates to address this policy challenge.

In the last two decades, recreational marijuana use has been mostly studied as an

illegal behavior in an illegal market. Moreover, in the last years, new studies have focused on the legal marijuana market. However, the literature considering a black market within a post-legalization market is scarce. To the best of my knowledge, Perrault (2022) is the only empirical article that considers a black market after legalization but has no information about consumer choices and assumes perfect access to both sources. In contrast, to estimate the effect of marijuana legalization, Jacobi and Sovinsky (2016) incorporates access selection in their demand model but does not distinguish between different (il)legal sources of marijuana. Hence, my paper stands as the first one that uses observed individual choices to estimate a demand where drug trafficking and legal marijuana are potential options, while also accounting for limited access to these alternatives.

This paper is organized as follows: Section 2 presents the related literature; Section 3 describes the institutional background; Section 4 explains the data used in this paper; Section 5 and 6 proposes the demand model and the econometric specification; Section 7 discusses the results; Section 8 shows the counterfactuals; and Section 9 presents the conclusions.

2 Related Literature

In recent years, with the ongoing discussions surrounding the legalization of recreational marijuana, there has been a significant increase in research on marijuana use. My paper is related to three different strands of the economic literature regarding this substance: (i) marijuana demand after legalization or decriminalization, (ii) legal marijuana market analysis, and (iii) the relationship between crime and marijuana legalization. Furthermore, this article is also aligned with research on demand estimation involving limited/consideration sets.

First, with the decriminalization or legalization of marijuana, researchers have primarily examined its potential increase in use. Existing evidence suggests that following decriminalization policies, overall marijuana use rises (Miron and Zwiebel, 1995; Pacula et al., 2010; Williams et al., 2011). However, it's crucial to note that legalization differs significantly from decriminalization. These two approaches vary in terms of accessibility, the associated costs of illegal behavior, and their impact on drug dealers. Jacobi and Sovinsky (2016) is the first article to estimate the impact of legalization on marijuana

use, predicting an increase in both intensive and extensive usage margins, where accessibility plays a role. Moreover, Miller et al. (2017) also finds an increase in the demand among college students in Washington (even among underage students) after its legalization. This increase could be attributed to reduced usage risks, lower prices, and improved accessibility (Perrault, 2022). These findings shape the debates on marijuana legalization. Such debates are critical since marijuana use can potentially elevate the likelihood of using harder drugs like cocaine or heroin (Van Ours, 2003; Bretteville-Jensen and Jacobi, 2011). However, existing literature primarily studies marijuana demand but not its sources, such as whether it originates from drug trafficking or the legal market. This novel analysis holds significant value for policymakers, as it aligns with their goal of curbing demand and ensuring a well-executed roll-out. In the current literature, Perrault (2022) proposes the only demand model that accounts for distinct marijuana sources as differentiated products. However, unlike this paper, it is estimated without observed choices and assumes all individuals have access to legal and illegal marijuana.

Second, in recent years, many studies have focused on the marijuana market directly as legal without considering the existence of a black market. With data from Washington, Hansen et al. (2017) assess the effect of taxation on the responses throughout the supply and consumption chain. Hollenbeck and Uetake (2021) suggests that legal marijuana is not overtaxed, with the majority of these taxes mainly carried by consumers. Additionally, regarding tax revenues, Miller and Seo (2021) shows that legal marijuana can cannibalize other legal substances' demand, while Hansen et al. (2020) analyzes the effect of a potency-based tax. Moreover, Thomas (2019) studies how inefficient the systems of license quotas are in the recreational marijuana market in Washington. Lastly, Perrault (2022) suggests that marijuana quality can serve as a tool to redirect demand toward the legal market. Nevertheless, no study has analyzed demand steering to the legal market where access to marijuana sources plays a role.

Third, a relatively new branch of the literature examines the effect of marijuana legalization on crime that arises from the prohibition of this substance. This potential effect is a significant motivator for legalization, particularly in areas where illicit drug production is significant. Studies have reported reductions in various crime rates following legalization (Dragone et al., 2019; Brinkman and Mok-Lamme, 2019), but with minimal effects on youth crime (Dills et al., 2017). Such effects have also been observed in U.S. states bor-

dering Mexico, where the legalization or decriminalization of the marijuana supply chain weakened criminal structures (Gavrilova et al., 2019). Moreover, Hao and Cowan (2020) analyzes an increase in marijuana possession arrests in neighboring states of Colorado and Washington, attributing it to a spillover effect following recreational legalization. However, no evidence is available on how crime and interactions with drug dealers influence the demand for marijuana in a post-legalized environment.

Lastly, by allowing for limited access, this project also extends the literature on limited choice/consideration sets. Jacobi and Sovinsky (2016) is the first article to model access to marijuana and use, while controlling for correlations, but does not consider sources (such as the drug trafficking or legal market). Several other articles, including Sovinsky Goeree (2008); Gaynor et al. (2016); Ho et al. (2017), explore situations where not all products are readily accessible to consumers (imperfect access) or where consumers may not be aware of all available products (imperfect information). This perspective is particularly relevant when considering illegal substances. Notably, this article is the first to define and differentiate limited access to marijuana based on its source.

The literature that considers a post-legalization black market in the marijuana demand is still very scarce. Overall, to the best of my knowledge, Perrault (2022) is the only empirical article that considers the presence of two options (illegal and legal) and analyzes the effect of legalization on the black market's marijuana prices and quality but has no information about consumers' sources. Particularly, the data and framework I employ in this article enable me to introduce a novel demand model that is estimated using observed consumer choices, while also considering limited access to drug trafficking and legal marijuana.

3 Institutional Background

3.1 Legalization of recreational marijuana in Uruguay

In Uruguay, a significant shift in marijuana legislation occurred in 1974 when the possession of a personal use amount was decriminalized under *Law 14,294*. However, production and commercialization remained prohibited. Then, in December 2013, Uruguay made history by becoming the first country to fully legalize recreational marijuana throughout

its entire territory.[2] This landmark change was brought about by *Law 19,172*, which empowered the government to regulate the recreational consumption, production, and distribution of marijuana.

This policy change was proposed and mainly pushed by Uruguayan President José Mujica.[3] Three primary objectives drove this initiative. First, the government sought to resolve the legal inconsistency of the prior law, where use was not criminalized, but commercialization was. Second, the government expected to enhance public safety by reducing drug trafficking-related violence and crimes. This objective held particular significance in a South American context, where the adverse consequences of drug trafficking, such as violence, disproportionately affect the global South (UNODC, 2023). Less developed regions face challenges like limited opportunities, resources, and law enforcement, making their residents more susceptible to involvement in drug cultivation, production, and distribution, further exacerbating drug-related issues. Finally, it aimed to use regulation as a public health measure.

The legislation, *Law 19,172*, was proposed directly from President Mujica's office as a *top-down* policy, deviating from the typical process involving initial engagement with activists, as seen in other countries. Around sixty percent of Uruguayans initially opposed this policy (Cifra Consultores, 2013). However, the government successfully pushed for this drug policy because citizens began to view marijuana legalization as a means to curb drug trafficking-related crimes and violence (Queirolo et al., 2019). This context differs from the approaches in other countries, where legalization is primarily proposed as a health policy (by regulating demand, supply, and quality) or a tool to raise taxes. In several Latin American nations, including Uruguay, various drugs are produced and then trafficked abroad, resulting in a pervasive drug trafficking market and the presence of *narcos*, generating a heavy toll on society. For instance, in 2014, an estimated 50 percent of violent deaths were linked to gang rivalries in the drug trafficking market (Ministerior del Interior, 2014).

The Uruguayan government capitalized on the fact that 40 percent of the population perceived 'delinquency' as the foremost issue in the country (Latinobarómetro, 2013) and presented this drug policy as an effective tool to undermine *narcos* by reducing their

[2]Canada followed suit in 2018, becoming the second country to legalize recreational marijuana. As of 2023, recreational use has been legalized at the state level in 23 states in the United States.

[3]José Mujica served as President from 2010 to 2015.

influence. In a June 2013 interview, President Mujica stated: *"The real problem is not marijuana but drug trafficking because consumption already exists in our society. If we do not seize the market from the drug traffickers, we induce the multiplication of the criminal world (...)"* (El Universo, 2013).

3.2 Sources of legal recreational marijuana

Uruguay's legalization framework provides three distinct sources for individuals to access marijuana for recreational use: authorized pharmacies, social cannabis clubs, and personal cultivation at home. The Institute of Regulation and Control of Cannabis (IRCCA) oversees and regulates the availability and distribution of marijuana through these channels.

To become a legal marijuana user in Uruguay, individuals must undergo a mandatory registration process. This registration is exclusively available to Uruguayan citizens or those with legal citizenship or permanent residence; tourists are not eligible. The registration process is cost-free and requires specific documentation, including a valid Uruguayan identity card (either natural or legal citizenship) and proof of residence. To complete the registration, individuals must visit designated facilities under the National Postal Service of Uruguay, where they can submit their documents. As of 2018, there were 27 authorized locations spread across the country to facilitate this process.

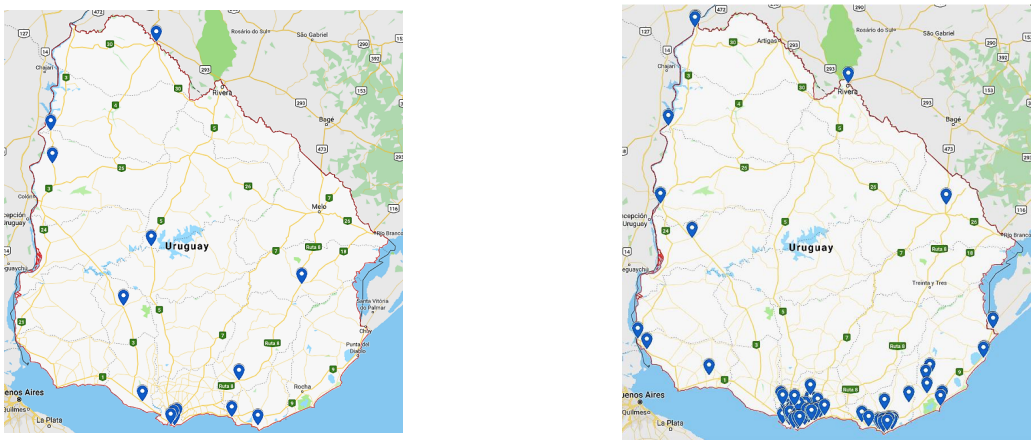
Home cultivators of marijuana in Uruguay are allowed to cultivate a maximum of 6 plants in their residence, with their annual production not exceeding 480 grams. As of 2018, 9,995 individuals had officially registered as home growers. These registered users had an average age of 36 years old, and roughly three-quarters of them were male. Notably, a significant portion of these registered home growers resided outside the capital city of Montevideo in 2018 (Instituto de Regulación y Control del Cannabis, 2018). However, it's worth noting that various studies indicate that a substantial portion of self-cultivators operate without official registration (Aguiar, 2018; Baudeau, 2018; Cruz et al., 2018). Evidence suggests that nearly half of the individuals who engage in home cultivation of marijuana do so without being formally registered. It's important to emphasize that the government does not prioritize enforcement measures against unregistered cultivators, as they are not seen as contributing to an increase in the drug trafficking market. Consequently, there is minimal enforcement for compelling individuals to undergo registration for home cultivation.

The second authorized source for obtaining legal marijuana in Uruguay is through cannabis social clubs. These clubs are permitted to cultivate a maximum of 99 plants, and the overall production of the club cannot exceed 480 grams per member annually. To establish a cannabis social club, there are specific requirements in place. Each club must have a minimum of 15 members and a maximum of 45 members. Additionally, a technical agent is mandatory to ensure that the club complies with all the requirements set by the regulatory institute. The registration of cannabis social clubs commenced in October 2014, and as of September 2018, the country had 107 clubs distributed across 11 different departments. These clubs collectively had a total membership of 2,703 individuals. On average, each club had approximately 25.3 members, and notably, approximately 80 percent were male, with an average age of 32 years old (Instituto de Regulación y Control del Cannabis, 2018).

Moreover, the third authorized source for obtaining legal marijuana in Uruguay is through authorized pharmacies, a system that commenced mid-2017. This initiative has gained notable attention and evolved significantly. As of September 2018, Uruguay had 14 pharmacies across the nation that were licensed to sell recreational marijuana. These pharmacies experienced significant demand, as evidenced by 28,181 registered buyers within the first year of implementation. Each pharmacy buyer was subject to a monthly acquisition limit of 40 grams, a regulation enforced through a fingerprint verification system, prioritizing privacy by eliminating the need for personal identification. These pharmacies are supplied exclusively by licensed producers, further ensuring the quality and legitimacy of the product. While the distribution of the pharmacies extends beyond Montevideo, the capital city remains a focal point, hosting most of these establishments. Consequently, more than half of the registered buyers are residents of Montevideo. The demographic profile of these buyers revealed a distinct trend, with nearly half of them falling within the age range of 19 to 29 years old (Instituto de Regulación y Control del Cannabis, 2018). This age distribution may indicate a significant engagement of young adults in Uruguay's burgeoning legal marijuana market.

Figure 1 offers a visual representation of the geographic distribution of authorized pharmacies and cannabis social clubs as of September 2018. Notably, a predominant concentration of these sources is evident in the south, where the population is densely clustered in the capital city, Montevideo (see Appendix A). Even though the locations

are correlated with highly populated zones, some areas do not have any legal source of marijuana. This is particularly significant for those residing outside the metropolitan areas. For individuals who find themselves at a distance from these authorized outlets, the only legal source is to engage in self-cultivation. This motivates my model of limited access to legal sources.



(a) Authorized pharmacies

(b) Cannabis social clubs

Figure 1: Locations of legal sources 2018 (Instituto de Regulación y Control del Cannabis, 2018)

4 Data

The primary dataset used in this paper is the VII National Survey on Drug Use in the General Population 2018 (NSDUGP). This survey was designed and coordinated by the Uruguayan Observatory of Drugs within the National Secretariat of Drugs. Conducted between September and December 2018, the NSDUGP includes individual-level data, such as socio-demographic attributes and information on drug use. Among the notable features explored are drugs' accessibility and use prevalence. The survey has a sample size of 4,720 individuals within the age range of 16 to 65 years. The dataset is nationally representative of 1.8 million individuals within the broader Uruguayan population, which totals 3.4 million inhabitants.[4]

Table 1 provides an overview of the socio-demographic characteristics. As the table shows, 45 percent of the individuals are male, while 82 percent identify as white. The

[4]Given the age bracket of the surveyed individuals and the sample selection of the departments, it does not represent the total population of the country.

average age of the respondents is 39, with 26 percent having attended college and 18 percent falling into a high socioeconomic status (defined by the public institutes involved in the survey). Additionally, a substantial majority, comprising 80 percent of the sample, reported their health status as good or very good. Furthermore, concerning the geographical distribution of the sample, 50 percent of individuals were residents of the capital city, Montevideo, while the remaining individuals resided in the country's interior departments. This distribution closely mirrors the population's geographic distribution.

Socio-demographics attributes	Mean	Min	Max
Male	0.45	0	1
Age (years)	39.41	15	65
White	0.82	0	1
Black	0.11	0	1
High school	0.49	0	1
Technical school	0.10	0	1
College	0.26	0	1
Unemployed	0.07	0	1
Middle level SES	0.51	0	1
High level SES	0.18	0	1
Good or very good health	0.80	0	1
Members in household	3.01	1	11
Lives in:			
Montevideo	0.50	0	1
Interior city (>20 thou.)	0.39	0	1
Interior city (<20 thou.)	0.11	0	1
Observations	4,720		

Table 1: Socio-demographics - NSDUGP

Table 2 summarizes individual drug usage patterns and accessibility to such substances. Findings from the survey indicate that 14 percent of respondents reported marijuana use within the past year, with 8 percent reporting use in the last month. Among those who had ever used marijuana, constituting 28 percent of the sample, the average age of initiation was 21 years. The survey extends its inquiry to include harder substances like cocaine and cocaine paste.[5] The annual prevalence rate of use for these hard drugs is 2 percent. Regarding drug accessibility, 76 percent of the individuals reported possible

[5]As common in these surveys and given the sensitive topics, individuals were provided with written assurance that none of their answers would be used against them and that anonymity would be guaranteed.

access to marijuana, while 61 percent indicated similar ease of access to (paste) cocaine. Additionally, 9 percent of respondents reported being offered the opportunity to purchase marijuana by a dealer, and 31 percent believe the often use of marijuana is risky for their health which may disincentive the consumption. Finally, respondents reported the number of friends and relatives using cocaine (paste), with an average response of 1.03.

Drug use and accessibility	Mean	Min	Max
Used marijuana ever	0.28	0	1
Used marijuana in the last 12 months	0.14	0	1
Used marijuana in the last 30 days	0.08	0	1
Age of first marijuana use	20.7	7	64
Used cocaine (paste) in the last 30 days	0.02	0	1
It is possible to obtain marijuana	0.76	0	1
It is possible to obtain cocaine (paste)	0.61	0	1
Was offered marijuana (to buy)	0.09	0	1
Believes often use of marijuana is risky	0.31	0	1
# friends/relatives that use cocaine (paste)	1.03	0	10
Observations	4,720		

Table 2: Drug use and accessibility information - NSDUGP

Besides individual attributes and marijuana use, for this paper, it is relevant to observe the source of marijuana, accessibility to this substance's sources, and prices. This information is explained in the following subsections and is a key ingredient for estimating the demand model.

4.1 Legal or drug trafficking marijuana

Given the main objective of *Law 19,172*, the Uruguayan Observatory of Drugs conducted this survey not only to assess the country's drug use rates but also to evaluate the effectiveness of the legalization of recreational marijuana and its legal sources. To achieve this, the survey gathered information from the individuals who had used marijuana in the past 12 months, specifically focusing on how they obtained the marijuana they often used. Users can be categorized based on whether the marijuana they often used originated from the legal market or the illicit drug trafficking market.

Table 3 provides the list of the marijuana sources. Users were asked to indicate their most frequently utilized source among these options. Then, legal marijuana encompasses

any marijuana originating (directly or indirectly) from self-cultivation, pharmacies, or social clubs.[6] Conversely, drug trafficking marijuana comprises marijuana originally obtained (directly or indirectly) from drug dealers. There are two *types* of marijuana in the market: "prensado," which is lower quality and often referred to as brick marijuana, and "cogollo," which refers to the marijuana bud (Appendix B presents pictures of these marijuana *types*). Marijuana buds are the flowers and the consumable parts of the plant. It's worth noting that before the establishment of legal marijuana sources, self-cultivation was the sole legitimate means of acquiring non-drug trafficking marijuana.

Legal marijuana sources	**Drug trafficking marijuana sources**
(1) I am a self-cultivator	**(1)** I bought *prensado* (brick marijuana) from a drug dealer.
(2) I am a club member	**(2)** I bought *cogollo* (marijuana bud) from a drug dealer
(3) I bought in a pharmacy	**(3)** Someone bought *prensado* (brick marijuana) for me from a drug dealer
(4) I bought to someone that cultivates or is a club member	**(4)** Someone bought *cogollo* (marijuana bud) for me from a drug dealer
(5) Someone bought for me in a pharmacy	**(5)** Drug trafficking marijuana was given/shared
(6) Someone bought for me to a self-cultivator or club member	
(7) Legal marijuana was given/shared	

Table 3: Sources of marijuana - NSDUGP

Table 4 presents an overview of the distribution of individuals who reported using marijuana within the past 12 months, categorized based on their primary source of marijuana. Specifically, marijuana users are classified as legal market users if their primary source of marijuana is one from the legal market or drug trafficking users if they primarily obtain marijuana from dealers. The 2018 survey reveals that 60 percent of users were legal market users, while 33 percent identified as drug trafficking users. Lastly, 7 percent of users lacked information about its source. In the marijuana demand literature, it is important to highlight that this individual-level classification is a completely novel feature, made possible by the detailed information collected by the NSDUGP.

[6]Non-registered home cultivation or buying from a legal user may technically be considered illegal. However, it operates within a "gray" market framework that does not impose the typical social costs of the illicit drug trafficking market. This paper focuses on the origin of the used marijuana.

Marijuana users	Freq.	Perc.
Legal users	370	60
Drug trafficking users	204	33
Unknown (Shared/Given)	43	7
Total	617	100

Table 4: Marijuana users - NSDUGP

4.2 Access to marijuana

4.2.1 Access to drug trafficking marijuana

Access to marijuana from the drug trafficking market is not perfect, as not every individual possesses the knowledge or means to obtain it. Only those who successfully have access can make the decision to use it or not.

The NSDUGP asked individuals how easy it is for them to obtain marijuana.[7] However, it is not possible to distinguish if they are referring to legal or drug trafficking marijuana. The survey question refers to *any* marijuana. Consequently, to precisely define access solely to the drug trafficking market, more specific information is necessary.

The NSDUGP collects information from both marijuana users and non-users, allowing the assessment of an individual's potential to acquire marijuana from drug dealers. Table 5 summarizes this information. I assume that an individual has access to the drug trafficking market if they meet any of the following criteria: (i) indicate that obtaining cocaine (paste)[8] is possible, (ii) have used cocaine (paste) within the last 12 months, (iii) have been offered marijuana for purchase in the last 12 months, or (iv) have used drug trafficking marijuana. Among the respondents, 61 percent reported the possibility of obtaining cocaine (paste), with 2 percent reporting use within the past year. Additionally, 9 percent of individuals were offered marijuana to buy (most probably by a drug dealer), and 5 percent have used drug trafficking marijuana in the last 12 months. Following this criteria, 65 percent of the sample has access to the drug trafficking market.[9] Moreover, the definition of access to the drug trafficking market largely hinges on the ability to obtain cocaine (paste). These individuals are more likely to be in direct contact with drug dealers

[7] A similar question was mainly used by Jacobi and Sovinsky (2016) in order to define marijuana access.

[8] Cocaine paste or coca paste, which is highly popular in South America and predominantly used by low-income populations, typically contains a cocaine concentration ranging from 40 to 80 percent.

[9] Note that certain conditions may overlap within the same individuals.

or knowledgeable about engaging with them. Moreover, it is reasonable to assume that if a dealer offers cocaine (paste), they can also provide access to drug trafficking marijuana.

Information about drug trafficking access	Percent
Is possible to obtain cocaine (paste)	61
Used cocaine (paste) in past 12 months	2
Was offered marijuana to buy	9
Used drug trafficking marijuana	5
Has access to the drug trafficking market	65
Used drug trafficking marijuana given access	18
Observations	4,720

Table 5: Drug trafficking market access - NSDUGP

Furthermore, individuals that fit into my definition of drug trafficking access also reported that it was *possible* to obtain *any* marijuana (see Appendix C). This validates the fact that individuals who have access to the drug trafficking market are able to obtain marijuana.

4.2.2 Access to legal marijuana

Access to legal marijuana is not perfect as well, as shown previously in Figure 1. With the NSDUGP, it is not possible to define access to the legal market at the individual level. Consequently, I establish access to the legal market for individuals residing in departments with a substantial number of legal marijuana users. In particular, I use the number of legal (registered) users per thousand inhabitants older than 18 years old. I consider this a better indicator of accessibility than the number of authorized pharmacies or clubs per department. They can be highly correlated, but the number of registered users can capture cases of two neighboring cities from different departments, where one may have a high number of legal sources and the adjacent city does not. Departments that have zero or a low number of legal users can easily signal limited or even non-existent accessibility to legal marijuana.

Table 6 shows the number of pharmacy buyers and club members per thousand inhabitants aged 18 or older. I define that a certain department does not have access to legal marijuana if it has 5 or fewer pharmacy buyers per thousand inhabitants older than 18 years old. This threshold is relatively low and the next department with a higher number

is relatively distant from it. More interestingly, the departments below this threshold exhibit a zero prevalence rate of legal marijuana (see Appendix D). Then, given this definition, individuals residing in Colonia, Florida, San José, and Tucarembó have no access to legal marijuana. Note that these departments also have zero or a low number of club members per thousand inhabitants older than 18 years old.

Departament	**Pharm. Buyers. (/1,000 inh.)**	**Club Members (/1,000 inh.)**	**Obs.**
Canelones	11.98	1.09	497
Colonia	3.15	1.13	187
Florida	3.88	0.37	235
Lavalleja	13.27	0	222
Maldonado	28.74	4.21	397
Montevideo	17.93	1.31	2,359
Salto	11.45	0.08	231
San Jose	4.97	0	410
Tacuarembó	4.36	0	182
Observations			4,720

Table 6: Legal marijuana users per thousand inhabitants (Instituto de Regulación y Control del Cannabis, 2018)

Consequently, 78 percent of the sample has access to legal sources of marijuana. Using the access definitions for these two marijuana alternatives, it is possible to define individual-level limited choice sets.

4.2.3 Access restrictions

As evidence shows, access is not perfect, not regarding the legal or the drug trafficking market of marijuana. Table 7 shows the sample distribution according to access restrictions. Notably, 53 percent of the sample has access to drug trafficking and legal marijuana. In addition, 25 percent (12 percent) have access only to drug trafficking (legal) marijuana, respectively. Lastly, 10 percent of the individuals do not have access to any marijuana. The table's last column also displays the marijuana use rate of each group. Individuals with full access exhibit the highest usage rate of 20 percent.[10] Within this rate, 12.2 percentage points are generated in the legal market, with the remaining portion sourced from the drug trafficking market.

[10]Note that this rate is significantly higher than the country's annual prevalence rate (see Table 2).

Access restrictions	**Perc.**	**Marij. use rate**
No access	10	0
Access only to legal marijuana	12	7.6
Access only to drug trafficking marijuana	25	5.9
Full access	53	20.0
Total	100	

Table 7: Access restrictions

Furthermore, Appendix E reviews the individuals' socio-demographic attributes according to their access restrictions. The highest fractions of individuals with a college education and high socioeconomic status have access only to legal marijuana. Note that these individuals may have self-selected not to have access to the drug trafficking market while residing in a department with sufficient legal sources.

4.3 Prices of marijuana

I do not observe the reported price paid from every user, for legal and drug trafficking marijuana. However, the NSDUGP asked marijuana users the price per gram of *cogollo* (marijuana bud) and *prensado* (brick marijuana). Table 8 presents the distribution of these reported individual prices per gram (in Uruguayan pesos, UYU). Naturally, marijuana buds tend to have a higher mean price than brick marijuana, as the latter is generally considered lower-quality marijuana, which is only obtained through drug dealers. Conversely, marijuana bud exhibits a larger standard deviation in price, reflecting the significant variation in quality which is unobserved.

Prices per gram (in UYU)	Mean	S.D.	Min	p10	p50	p90	Max
Brick marijuana *(prensado)*	59.1	33.2	10	20	50	100	150
Marijuana bud *(cogollo)*	123.8	59.9	20	50	100	200	250

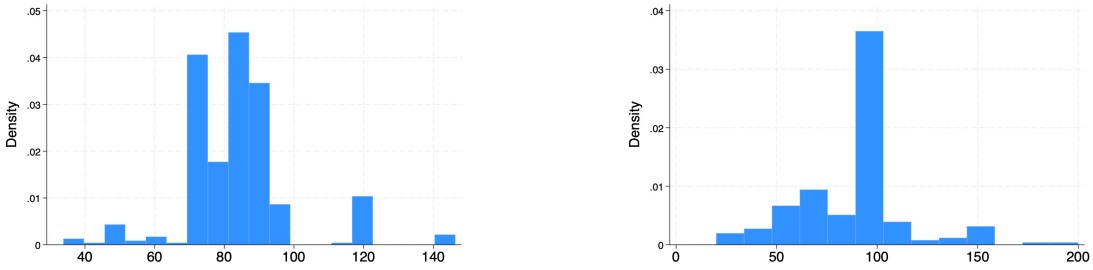
1 USD = 32 UYU (2018)

Table 8: Reported prices per gram of brick and marijuana bud

Moreover, the marijuana sold in authorized pharmacies is regulated and is 80 UYU per gram. For users, I use these data to construct an individual-level price per gram for drug trafficking and legal marijuana. First, the price of drug trafficking marijuana is taken

as the drug trafficker users' average of their reported illegal marijuana bud price and the brick marijuana price.[11] Second, the price of legal marijuana is taken to be the legal user's average of their reported marijuana bud price and the pharmacy marijuana price.[12] This price construction reflects the market price that users face, whether it is the legal market or the drug trafficking market, and it is not specific to any particular location.

Figure 2 shows the distribution of these generated prices for drug trafficking and legal users. The average price for legal marijuana is 83.6 UYU, while 87 UYU for drug trafficking marijuana. For legal marijuana, prices are concentrated between 70 and 90 UYU, whereas drug trafficking prices tend to be concentrated around 90 UYU.



(a) From legal market

(b) From drug trafficking market

Figure 2: Distribution of individual-level marijuana prices (in UYU)
1 USD = 32 UYU (2018)

For the non-users, for each marijuana alternative, I imputed the price using the observed average of four age groups: younger than 20 years old, between 20 and 30 years old, between 30 and 40 years old, and older than 40.[13] Age was the socio-demographic attribute that explained high price variations. This imputation, according to a socio-demographic attribute, follows as performed in Jacobi et al. (2023). Appendix F shows the prices generated for non-users, according to their age. Teenagers and individuals older than 40 have a lower average price for each option. The literature typically focuses on average market or period prices. However, it's crucial to acknowledge that individuals encounter varying scenarios when purchasing marijuana, impacting the price.

[11] As shown in Table 3, brick marijuana is only found in the drug trafficking market.
[12] Legal users can buy marijuana buds that were originally produced in legal sources, such as clubs.
[13] For every users from which an input is not observed, I also impute it in this way.

5 Model

I consider the following marijuana demand model, where the individual $i = 1, ..., N$, in the department $t = 1, ..., T$, decides whether to have access to the drug trafficking market or not. I model this access selection as being determined by the following utility function:

$$U_{it}^{a} = \beta^{a} + \gamma^{a} X_{i}^{a} + \eta^{a} Z_{t}^{a} + \varepsilon_{i}^{a} \tag{1}$$

Where, X_i^a is a set of the individual's socio-demographics, which includes age, gender, education, race, and socio-economic status. Then, Z_t^a is a set of department-specific characteristics that may affect access to illegal drugs, such as crime information. Lastly, ε_i^a is an unobserved term that affects the individual's likelihood of accessing drug trafficking drugs.

In this model, individuals with access to the drug trafficking market can choose to use drug trafficking marijuana or not. On the other hand, legal marijuana is available depending on individual i's location (as mentioned in subsection 4.2.2). I assume that individual i does not decide where to live based on legal sources of marijuana, and instead, accessibility to legal marijuana is exogenous.

Furthermore, conditional on the choice set, individual i, in department t, can choose between $j = 0, 1, 2$: no use of marijuana, use of legal marijuana, or use of drug trafficking marijuana, respectively. Note that legal and drug trafficking marijuana are modeled as differentiated products. This alternative choice is based on the following indirect utility:

$$U_{itj}^{u} = \beta_{j}^{u} - \alpha p_{ij} + \gamma_{j}^{u} X_{i}^{u} + \eta_{j}^{u} Z_{t}^{u} + \nu_{itj} + \varepsilon_{i}^{u} \tag{2}$$

Where, β_j^u is the constant term for each $j > 0$ (alternative fix effect), p_{ij} is the individual level price for product j, X_i^u is a set of individual-level attributes (such as age, gender, education, race, socio-economic status, health status and risk adverseness), and market-level attributes Z_t^u that affect the demand choice (such as the number of pharmacy buyers per capital). Finally, ν_{ijt}, a type 1 extreme value error, is the unobserved shock of i of choosing alternative j. Moreover, ε_i^u is the individual's unobserved term of using (any) marijuana. The ε_i^u can be explained as coming from a random coefficient in the

constant term: $\beta_{ji}^u = \beta_j^u + \varepsilon_i^u$.[14]

The utility of the outside option is $U_{it0} = \nu_{it0}$. It does not include the ε_i^u since $j = 0$ represents the decision of not using marijuana. Consequently, this allows for a particular substitution of the $j > 0$ alternatives given the unobserved term of use ε_i^u.

In addition, I assume that the idiosyncratic shocks to access and use (demand), ε_i^a and ε_i^u, are distributed according to the following (standardized) multivariate normal distribution:

$$\begin{pmatrix} \varepsilon_i^u \\ \varepsilon_i^a \end{pmatrix} \sim \mathcal{N}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right) \tag{3}$$

The parameter ρ captures the potential correlation between these unobserved terms. If the correlation is positive, an individual with a higher unobservable propensity to access the drug trafficking market is also more likely to use (any) marijuana. The opposite could also hold: an individual who is highly interested in using marijuana will potentially find their way to obtain drug trafficking marijuana as the only or an additional option of marijuana (or even another illegal drug).

6 Econometric specification

An individual will choose to have access to drug trafficking marijuana if $U_{it}^a > 0$. Then, the probability that individual $i = 1, ..., N$, in department $t = 1, ..., T$, has access to the drug trafficking market is as follows:

$$\phi_{it} = \Pr_{it}(a_{it} = 1) = \int I(\beta^a + \gamma^a X_i^a + \eta^a Z_t^a + \varepsilon_i^a > 0) f(\varepsilon_i^a) d\varepsilon_i^a \tag{4}$$

Where, a_{it} is a dummy that indicates if the individual has access to the drug trafficking market or not, and ε_i^a is distributed normally.

Given the individual's access selection and geographic location, then (s)he will have a limited choice set $\mathcal{C}_\rangle$. An individual will choose alternative $j \in \mathcal{C}_\rangle$ if $U_{itj}^u > U_{itk}^u$, where $j \neq k$. Given the assumptions of the unobserved terms, the probability of individual i, in department t, chooses the good $j \in \mathcal{C}_\rangle$ is:

[14] This is similar to Ioannidou et al. (2022) and Crawford et al. (2018) where different financial decisions are allowed to be correlated through the unobserved terms

$$s_{itj\in\mathcal{C}_\rangle} = \int \frac{exp(\beta_j^u - \alpha p_{ij} + \gamma_j^u X_i^u + \eta_j^u Z_t^u + \varepsilon_i^u)}{1 + \sum_{j\in\mathcal{C}_\rangle} exp(\beta_j^u - \alpha p_{ij} + \gamma_j^u X_i^u + \eta_j^u Z_t^u + \varepsilon_i^u)} f(\varepsilon_i^u) d\varepsilon_i^u \tag{5}$$

Where, the type 1 extreme error term, ν_{ijt}, generates the closed-form solution inside the integral. In addition, the probability that individual i in market t chooses the outside option (not using marijuana) is:

$$s_{it0} = 1 - \sum_{j\in\mathcal{C}_\rangle, j\neq 0} s_{itj} \tag{6}$$

Note that if an individual has access to no marijuana, $\mathcal{C}_\rangle = \{0\}$, then (s)he will choose the outside option with certainty. However, the decision of whether to have access to drug trafficking marijuana remains relevant for this individual.

Moreover, the random draws that impact access selection and use are specified as follows:

$$\varepsilon_i^a = \xi_i^a \tag{7}$$

$$\varepsilon_i^u = \rho\xi_i^a + \sqrt{(1-\rho^2)}\xi_i^u \tag{8}$$

Where, $\xi_i^a, \xi_i^u \sim N(0,1)$. So, ρ will capture the correlation of the unobserved shocks of the access selection to drug trafficking marijuana and the use of any marijuana.

I estimate the model by simulated maximum likelihood. Halton draws ($S = 100$) are used to approximate the integrals,[15] and each draw is indexed by s. The joint estimation of these two choice equations is based on the following log-likelihood function:

$$\log L = \sum_i \frac{1}{S} \sum_{s=1}^{S} \mathrm{a}_{it} \left(\log(\phi_{its}) + \mathbf{d}_{itj}\log(s_{itjs})\right) + (1 - \mathrm{a}_{it}) \left(\log(1 - \phi_{its}) + \mathbf{d}_{itj}\log(s_{itjs})\right) \tag{9}$$

Where, a_{it} is the dummy that refers to the individual's access selection for drug trafficking marijuana, and $\mathbf{d}_{itj}$ is the dummy for the individual's use of $j \in \mathcal{C}_\rangle$.

[15] According to Train and Winston (2007), these number of draws achieve greater accuracy in mixed logit estimations than 1,000 pseudo-random draws.

6.1 Identification

The parameters of the utilities of the access selection to drug trafficking marijuana and the marijuana use decision are estimated due to variation in the data at the individual- and department-level, which corresponds to variation in the probabilities of these two decisions. It is important to note that both the alternative fixed effects and the price coefficient can be identified due to the price variations at the individual level.

Moreover, the parameter ρ can be estimated due to variance in the covariance between unobservables terms that affects the access selection to drug trafficking marijuana and the marijuana use decision. To allow for identification beyond the model nonlinearities, I include exclusion restrictions in the access selection. In particular, I have included two variables that should not affect the utility of using any of the marijuana alternatives. The first variable is the department's number of homicides rate per 100 thousand inhabitants (see Appendix D), as a proxy of violence or crime. The presence of drug-related gangs generates the availability of drugs, but also high violence in the locality. It is estimated that half of the homicides are due to drug trafficking conflicts (Ministerior del Interior, 2018), given their search for more territory or power. Furthermore, the second variable that exclusively impacts the likelihood of access is generated with the individual's reported number of friends or relatives that use hard drugs. In particular, with that report, I generate the average per department (see Appendix D). This variable would also reflect the department's level of presence of illegal drugs. Higher levels of these two variables are expected to increase the likelihood of the individual's access to the drug trafficking market, without influencing the utility of using marijuana.

7 Results

Table 9, columns (2) and (3) present the coefficients of a model without access restrictions, which is a multinomial logit where every individual has a full choice set: $\{0, 1, 2\}$. Here, there is no access selection to drug trafficking marijuana, and in every department, legal marijuana is available. Moreover, in columns (3)-(5), I show the coefficients of the model with access restrictions proposed in this article: with access selection to drug trafficking marijuana and individual choices sets.

First, the model with access restrictions estimates a larger price coefficient than the

model without access restrictions. This is consistent with previous literature considering limited access, as in Jacobi and Sovinsky (2016). Regarding individual attributes, all specifications consistently show that male and college-educated individuals have a higher marginal utility of using marijuana, regardless of the source. However, in the model with access restrictions, college-educated individuals get more utility from using legal marijuana as compared to the drug trafficking option. In contrast, individuals who are older, in good health, and exhibit risk-averse behavior toward marijuana use[16] have a lower marginal utility of using this substance. These negative coefficients on marijuana use utility are even more pronounced when considering drug trafficking marijuana. Two variables have different effects according to the alternative. Individuals who identify as belonging to minority races[17] get less (more) utility from using legal (drug trafficking) marijuana. Furthermore, a high socioeconomic status[18] increases the individual's utility of using legal marijuana but has a negative effect regarding the drug trafficking alternative. In addition, an individual who lives in a department with more pharmacy buyers gets more utility from using legal marijuana.

Being able to obtain marijuana from the drug trafficking (DT) market is not random. As shown in column (5), the same individual-level attributes impact the utility of this access selection. Males and individuals belonging to a minority race have a higher marginal utility from being able to obtain illegal drugs, while older individuals and those with a high socio-economic status get a lower utility from this selection. Having a college education has a statistically insignificant effect on this selection's utility. As expected, crime, measured through the department's homicides per 100 thousand inhabitants, generates more utility regarding access to illegal drugs. Similarly, the department's average number of friends and relatives who use cocaine (paste) also positively affects the utility of this selection. This implies that departments with higher crime levels and a more significant presence of hard drugs increase an individual's utility regarding having access to the drug trafficking market.

Finally, selection is also in the unobservables, as evidenced by the parameter ρ being positive and statistically significant. In particular, the correlation is equal to 0.4. This positive correlation underscores the importance of considering access selection into the

[16] Thinks the often use of marijuana is risky (as described in Table 2).
[17] Black, aboriginal, Asian or other.
[18] The National Institute of Statistics defines three levels: low, medium, and high.

drug trafficking market in the marijuana use decision. Notably, a similar positive and significant correlation was estimated by Jacobi and Sovinsky (2016), further validating the importance of allowing for this correlation.

	Without Access Restrictions		**With Access Restrictions**		
	Demand		**Demand**		**Access DT**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
price	-0.0625***		-0.0683***		
	(0.0031)		(0.0028)		
	Legal	**Drug-Traff.**	**Legal**	**Drug-Traff.**	
male	0.8353***	0.7827***	0.9656***	0.8160***	0.2820***
	(0.1630)	(0.1956)	(0.0609)	(0.0585)	(0.0223)
college	0.8540***	0.2265	0.9022***	0.2274***	0.0105
	(0.1809)	(0.2604)	(0.0612)	(0.0602)	(0.0283)
minority race	-0.2930	0.2702	-0.2413***	0.2019**	0.1808***
	(0.2208)	(0.2135)	(0.1007)	(0.0854)	(0.0531)
age	-0.0521***	-0.0958***	-0.0625***	-0.1060***	-0.0110***
	(0.0064)	(0.0097)	(0.0023)	(0.0035)	(0.0004)
high SES	0.1731	-0.9974***	0.2024***	-0.9006***	-0.3145***
	(0.1961)	(0.3732)	(0.0906)	(0.0955)	(0.0342)
good health	-0.5081**	-1.0351***	-0.5947 ***	-1.1308***	
	(0.2130)	(0.2261)	(0.0428)	(0.0633)	
risk adverse	-2.2430***	-2.5138***	-2.4687***	-2.7048***	
	(0.3910)	(0.5426)	(0.2046)	(0.2277)	
pharm buyers pc	0.0507***		0.0146***		
	(0.0130)		(0.0045)		
homicides pc					0.1495***
					(0.0042)
# friends cocaine					0.6824***
					(0.0604)
constant	-2.2220***	0.7550*	-1.4417***	0.7254***	0.8034***
	(0.3704)	(0.4178)	(0.0471)	(0.0534)	(0.0160)
ρ				0.4139***	
				0.0221	
Likelihood	1,067		3,280		
N	4,687		4,687		4,687

Note: Standard errors in parenthesis.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 9: Estimation results

Table 10 shows the computed own- and cross-price elasticities of the model with and

without access restrictions, regarding legal and drug trafficking marijuana. These elasticities represent the percentage change in demand for the alternatives when there is a one percent increase in the price of the same or a different alternative. The elasticities, ϵ_{jk}, are presented considering the alternative j's demand (in the rows) given a price variation in the k alternative (in the columns). The model with access restrictions yields greater own-price elasticities, in absolute terms, than the model without access restrictions. In the model with (without) access restrictions, the own-price elasticity is -0.97 (-0.83) for legal marijuana and -0.85 (-0.72) for drug trafficking marijuana. Moreover, cross-price elasticities are also crucial for public policy considerations. I find that the model without access restrictions underestimates the cross-price elasticities.

Price elasticites (ϵ_{jk})	Legal marij..	Drug traf. marij.
With access restrictions		
Legal marij.	-0.97	+0.25
Drug traf. marij.	+0.27	-0.85
Without access restrictions		
Legal marij.	-0.83	+0.18
Drug traf. marij.	+0.22	-0.72

Table 10: Price elasticities

8 Counterfactuals

Policymakers have a vested interest in understanding the demand in this particular context to steer it toward the legal and legal marijuana market effectively. When the drug trafficking market experiences a decline in demand, it can result in reduced profits, presence, and violence associated with the illegal drug trade. In addition to the positive externalities of a weaker drug trafficking market, individuals may lose contact with drug dealers. While some individuals may engage with dealers solely to obtain marijuana, it is important to note that dealers can also serve as sources for harder drugs like cocaine, cocaine paste, and heroin. Disrupting the user-dealer relationship may consequently reduce individuals' access to harder drugs, which aligns with the goal of minimizing the negative health effects associated with these substances.

To shift demand away from the drug trafficking market and towards the legal market, the government may consider implementing policies that enhance the accessibility

or attractiveness of the legal market or make the drug trafficking market less accessible. Moreover, it is important to mention that curbing the demand is also a government's objective. Some strategies may successfully attract drug trafficking users to the legal market while also increasing the overall marijuana use rate. Introducing new users to the market is not a desirable outcome from the government's perspective. For this reason, it is important to observe how substitutions are performed when using a credible shifting tool.

In particular, first, I analyze a reduction in the price of legal marijuana. Second, I explore how a reduction in drug trafficking presence, determined by department-level variables, influences access to drug trafficking marijuana and the marijuana use decision. Lastly, I introduce legal marijuana as an option within the choice set of every individual and assess the effect of perfect access to this alternative.

8.1 Legal price reduction

The pricing of legal marijuana is defined by IRCCA, with pharmacies having no control over it. Therefore, implementing price reductions becomes a direct strategy for encouraging more users to transition from the drug trafficking market to the legal one. To achieve this without negatively impacting authorized marijuana suppliers, the government could consider reducing the regulated price.

I perform two legal price reductions: 5 and 10 percent. The results are shown in the Table 11. Column (1) presents the predicted baseline market shares and columns (2)-(3) show the percentage point changes resulting from the respective legal price reductions.

Alternative	**(1) Predicted market share** (percentage)	**(2) Legal Price ↓ 5%** (Δ percentage points)	**(3) Legal Price ↓ 10%**
No use ($j = 0$)	85.4	-0.3	-0.7
Legal marij. ($j = 1$)	9.5	+0.4	+0.9
Drug traf. marij. ($j = 2$)	5.1	-0.1	-0.2
Marijuana use rate	14.6	+0.4	+1

Table 11: Predicted market shares and counterfactuals (legal price reduction)

As expected, the demand for legal marijuana increases following its price reduction. Remarkably, across the various legal price reductions, a significant portion of the shift toward the legal market originates from the outside option (from non-users). It's worth

noting that a large fraction of the increase in the legal market share can be attributed to the decrease in the outside option share. For example, with a 10 percent reduction in the legal price, the drug trafficking market share decreases by 0.2 percentage points, while marijuana use increases by a much larger fraction. Given the limited access to legal marijuana, it is impossible to attract potential marginal users (drug trafficking users that may be easily shifted). Moreover, where legal marijuana is already available, attracting these marginal users with lower prices becomes more challenging, given a low cross-price elasticity.

Given the novel ingredients of the model with access restrictions, realistic substitutions are observed (consumers substitute from one available alternative to another available one). However, predictions of the model without access restrictions will underestimate the increase in the overall marijuana use rate, given lower price elasticities. In addition, it will capture non-possible substitutions, considering that without access restrictions every individual has a full choice set (see Appendix G). Then, even though some individuals have no access to a certain marijuana alternative, they will have a non-zero probability of choosing it.

8.2 Decreasing access to the drug trafficking market

Another potential tool at the government's disposal for steering the demand is reducing the presence of the drug trafficking market. Various policies could be enacted to target drug-related gangs and organizations directly. In particular, with a diminished drug trafficking market, individuals would be less likely to come into contact with drug dealers when seeking marijuana or other illegal substances.

If drug trafficking is reduced, it should be reflected in two variables considered in the access selection in the model with access restrictions. First, violence and crime, measured through the department's homicide rate, should decrease. A decrease in drug-related conflicts, which typically contribute to violence, would be expected with fewer drug traffickers. However, it's worth noting that approximately half of this measure is attributed to drug-related conflicts, so this aspect needs to be considered in the counterfactual analysis. Secondly, the department's average number of friends and relatives who use hard drugs should also decrease. This serves as a close proxy for the presence of illegal and hard drugs. With drug-related gangs weakened, the availability of illegal drugs would also

likely decrease. These two measures are directly or closely related to the drug trafficking of harder drugs. However, if fewer dealers are available due to a reduction in drug trafficking, it should also lead to a decrease in the access and use of illegal marijuana.

I simulate two reductions in the department's drug trafficking presence through these variables: 50 and 75 percent. Table 12 shows the results of this analysis. Again, column (1) presents the baseline predicted market shares, and columns (2)-(4) indicate the changes in percentage points resulting from the corresponding counterfactuals. The department's average number of friends and relatives who use hard drugs is reduced by either 50 or 75 percent, while the homicide rate is decreased using only the portion attributed to drug-related issues.

Alternative	**(1)** **Predicted market share** (percentage)	**(2)** **Drug. Traff.** **↓ 50%** (Δ percentage points)	**(3)** **Drug. Traff.** **↓ 75%**
No use ($j = 0$)	85.4	+0.3	+0.8
Legal marij. ($j = 1$)	9.5	-0.2	-0.5
Drug traf. marij. ($j = 2$)	5.1	-0.1	-0.3
Marijuana use rate	14.6	-0.3	-0.8

Table 12: Predicted market shares and counterfactuals (drug trafficking market access reduction)

A reduction in these variables directly impacts an individual's likelihood of accessing the drug trafficking market. This, in turn, results in a reduction in the demand for drug trafficking marijuana. Interestingly, the market share of legal marijuana also decreases. This arises from the fact that the choice of accessing the drug trafficking market is correlated with using any marijuana alternative. If an individual loses contact with a dealer and illegal drugs, they become less likely to use marijuana, even if a legal option is available. However, it's noteworthy that a reduction in the drug trafficking market share is relatively small. Specifically, a 75 percent reduction in the variables capturing drug trafficking presence results in only a 6 percent decrease (0.3 percentage points) in the drug trafficking marijuana market share.

8.3 Increasing access to legal marijuana market

Finally, the government could increase the accessibility of legal marijuana to attract more users. To achieve this, it should implement policies to encourage potential suppliers to expedite the delivery of marijuana to pharmacies, as bureaucratic obstacles have hindered the supply chain. By enhancing accessibility to the legal market, every individual would have legal marijuana as an option in their choice set, thereby generating a nonzero probability of choosing this alternative.

It is important to note that these counterfactuals are motivated by two facts. Firstly, increased accessibility could be achieved through the authorization and supply of existing pharmacies, which do not require the initial investment as new dispensaries. Secondly, departments without these legal sources have comparable marijuana use rates to other departments with access to sufficient legal sources (see Appendix D), indicating that legal supply can meet demand. Table 13 shows the substitutions generated by these assumptions. Column (2) presents how the market shares vary given that every individual has access to legal marijuana (legal marijuana is in every choice set).

Alternative	**(1)** **Predicted market share** (percentage)	**(2)** **Perfect access to legal marijuana** (Δ percentage points)
No use ($j = 0$)	85.4	-0.8
Legal marij. ($j = 1$)	9.5	+1.6
Drug traf. marij. ($j = 2$)	5.1	-0.8
Marijuana use rate	14.6	+0.8

Table 13: Predicted market shares and counterfactuals (legal market increase)

As expected, the market share of legal marijuana increases. But interestingly, this increase of 1.6 percentage points (17 percent), half of the substitution comes from users who chose the drug trafficking alternative. This was not the case when reducing the legal price with limited access, where more news users are generated. This particular substitution occurs given that marginal users are quickly attracted to the legal market when it becomes available. In other words, given their (un)observed attributes, some individuals may be just waiting for a legal option in order to switch to it. From the government's perspective, these users should be easy targets. Even though there may be

drug trafficking users that would be hard to switch, accessibility may be a key ingredient to diminish the drug trafficking market, with a desirable substitution.

8.4 Discussion of the counterfactuals

Policymakers face the challenge of making the legal marijuana market more attractive while simultaneously curbing marijuana use. The insights gained from the counterfactual analyses provide the following valuable lessons:

1. Limited access to legal sources makes price an inefficient tool for steering demand. Evidence suggests that cross-price elasticity is relatively small.[19]

2. Efforts to reduce access to the drug trafficking market can effectively reduce the overall marijuana use rate. Users and potential users lose their contact with drug dealers, which decreases their inclination to use drugs, including marijuana, whether it is legal or not.

3. Enhancing accessibility to the legal market appears to be the most efficient way to steer demand. The overall marijuana use rate increases, but almost half of the increase is generated by drug trafficking users now choosing the legal alternative.

Policies that enhance access to marijuana may be hindered by a larger incentive to curb the demand or by bureaucratic processes in this new market. However, analyzing the demand in a post-legalized context reveals that the overall marijuana use rate will increase due to policies aimed at steering the demand. Nonetheless, policymakers can adopt strategies to ensure that the increase in marijuana use is mostly generated by reducing the drug trafficking market.

9 Conclusions

Recreational marijuana legalization is often proposed as a tool to diminish the consequences of drug trafficking-related conflicts, which are prevalent in many countries. However, even after the legalization, a significant portion of users may continue to obtain

[19] Perrault (2022) also estimates low cross-price elasticities, regarding legal and illegal marijuana.

this substance through the drug trafficking market. The slow market transition allows drug dealers to maintain their influence and contact with users.

In this paper, I propose a novel and adequate demand model that considers different aspects of a post-legalized environment, such as access selection/limitations, alternative choice regarding source (as differentiated products), and individual-level prices. By incorporating these ingredients to predict demand, it becomes feasible to identify effective tools for steering demand toward the legal market. This information is valuable for crafting efficient policies aimed at reducing the presence of drug traffickers in the market and mitigating their harmful societal consequences. In particular, I find that legal price reduction is an inefficient tool for this objective. However, access plays a crucial role and can be used as a proper tool to generate desirable substitutions that mostly decrease the presence of the drug trafficking market.

Understanding the behavior of a new market is not a simple task, particularly when it comes to a substance with a long history of illegality. Post-legalization, there are many aspects that we need to learn regarding marijuana demand and research should tackle these questions. Considering that the war against drug traffickers has been too long and too costly, it is essential not only to understand the demand for marijuana but also the factors influencing the choice of its source.

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A Uruguay population density

Figure 3: Uruguay population density in 2020 (Geo-Ref, 2021)

B Marijuana types

(a) Marijuana brick

(b) Marijuana bud

(c) Pharmacy Marijuana

Figure 4: Marijuana

C Accesibility to marijuana

Able to obtain Marijuana	**No Access to Drug.Traff Market**	**Has Access to Drug.Traff Market**
Possible to obtain marijuana	614	2,960
Impossible to obtain marijuana	248	0
Do not know	811	87
Do not know	1,673	3,047

Table 14: Homicide rates by department (2018)

D Department-level information

Department	Homicides (per 100 thou. inhabitants)	Marij.use rate (annual prevalence)	Legal Marij. use rate (annual prevalence)
Montevideo	16.1	17.5	11.2
Canelones	8.7	13.4	8.4
Colonia	4.6	9.6	0
Florida	7.2	6.4	0
Lavalleja	8.5	6.3	4.1
Maldonado	11.6	10.6	5.9
Salto	9.0	7.4	3.5
San Jose	5.2	7.3	0
Tacuarembó	9.7	6.3	0

Table 15: Department level information

Department	Average number of friends/relatives that use hard drugs
Montevideo	16.1
Canelones	1.11
Colonia	0.56
Florida	0.64
Lavalleja	0.37
Maldonado	1.07
Salto	1.33
San Jose	1.09
Tacuarembó	0.59

Table 16: Department level information

E Socio-demographics by access restrictions

Socio-deomographic	No access	Only Drug traff.	Only Legal	Full access
	(in percent)			
Male	41	51	36	48
College	18	19	31	27
Minority race	17	22	14	20
Age (in years)	42	38	43	27
High SES	14	13	26	17

Table 17: Socio-demographics by access restrictions

F Imputed prices for non-users

Age group	**Legal market**	**Drug trafficking market**
Younger than 20 years old	77.3	90.8
Between 20-30 years old	84.6	91.3
Between 30-40 years old	88.6	94.4
Older than 40 years old	73.3	80.7
Average price	78.1	85.9

Table 18: Imputed prices (in UYU)

G Legal price reduction with model without access restrictions

Alternative	**(1)** **Predicted market share** (percentage)	**(2)** **Legal Price ↓ 5%** (Δ percentage points)	**(3)** **Legal Price ↓ 10%**
No use ($j = 0$)	85.4	-0.2	-0.5
Legal marij. ($j = 1$)	9.4	+0.3	+0.7
Drug traf. marij. ($j = 2$)	5.1	-0.1	-0.2
Marijuana use rate	14.5	+0.3	+0.7

Table 19: Predicted market shares and counterfactuals with model without access restrictions (legal price reduction)