Myths of drug consumption decriminalization: effects of Portuguese decriminalization on violent and drug use mortality

Lucas Marín Llanes

Hernando Zuleta

Abstract

There is scarce empirical evidence on the impacts of drug consumption decriminalization, especially, on problematic drug use and violence. In 2001, Portugal decriminalized the consumption of all illicit drugs. In this paper, we focus on determining the short, medium, and long-term impact of Portuguese decriminalization on mortality due to drug use and homicides, from both theoretical and empirical perspectives. We model drug consumption using an intertemporal consumption model and the decisions of trafficking firms to gain market share employing an optimization model. Our results suggest a non-linear effect of decriminalization on drug consumption risk and increasing incentives for firms to expand their market share employing violence after decriminalization. Empirically, we estimate a negative short-run effect on drug-related deaths and null long-run impacts of this legal reform. In terms of homicides, we find a positive effects in a range of 28.7%-34.2% in the medium- and long-term.

Key words: Illicit drugs, decriminalization, drug policy reform, consumption drug-related deaths, homicides.

JEL codes: K14, K38, K42, I18

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2 Predoctoral Fellow, Centro de Estudios de Seguridad y Drogas (CESED), School of Economics – Universidad de Los Andes. E-mail: l.marinl@uniandes.edu.co

3 Full Professor, School of Economics – Universidad de Los Andes. E-mail: h.zuleta@uniandes.edu.co
Mitos de la descriminalización del consumo de drogas: efectos de la descriminalización en Portugal en muertes violentas y por uso de drogas

Lucas Marín Llanes
Hernando Zuleta

Resumen

La evidencia frente a los impactos de la descriminalización del consumo de drogas es escaza, especialmente en cuanto al consumo problemático de estas sustancias y en violencia. En 2001, Portugal descriminalizó el consumo de todas las sustancias ilícitas. En este artículo determinamos, teórica y empíricamente, los efectos de corto, mediano y largo plazo de la descriminalización en Portugal en la mortalidad asociada al consumo de drogas y homicidios. Modelamos el consumo de drogas con un modelo dinámico y las decisiones de las firmas vendedoras de sustancias a través de un modelo de optimización. Nuestros resultados sugieren un efecto no lineal de la descriminalización en el riesgo asociado al consumo y un aumento en los incentivos que tienen las firmas para aumentar su poder de mercado por medio de métodos violentos. Empíricamente, estimamos un efecto negativo de corto plazo de la descriminalización en muertes relacionadas con el consumo de sustancias y, en el largo plazo, el efecto es estadísticamente igual a cero. En el caso de los homicidios, encontramos que la descriminalización aumentó este indicador en 28.7% y 34.2% en el mediano y largo plazo, respectivamente.

Palabras clave: Drogas ilícitas, descriminalización, reforma a la política de drogas, muertes relacionadas con consumo, homicidios.

Códigos JEL: K14, K38, K42, I18

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1. Introduction

Does drug consumption decriminalization have a long-term impact on drug-related deaths and homicides? There is no consistent evidence nor theoretical conclusive arguments to answer this question. The purpose of this paper is to contribute with both theoretical and causal empirical evidence employing the case of Portugal, where the consumption of all illegal substances was decriminalized in 2001. Since the policy became effective, the legal framework towards drug possession and consumption changed radically. Decriminalization focused on warning, imposing small fines, promoting treatment, harm reduction, and help-seeking behaviors in health institutions instead of arresting people for possessing or consuming psychoactive substances. In this sense, what we evaluate in this paper is the joint effect of the measures carried out together with the decriminalization.

We present a theoretical framework to analyze the effect of drug consumption decriminalization on the risk of drug-related deaths and homicides. It is worth mentioning that the effect we estimate in this paper is not limited to the legal framework reform, but our definition of decriminalization includes all the changes enabled by the legal framework reform such as the more comprehensive public health approach for substance use, among others.

We build a simple model where users derive utility from drug use, but also react to the perceived risk in such a way that when the perception of risk increases, consumption falls. The model predicts a nonlinear effect of decriminalization on drug-related death risk. First, decriminalization reduces consumption risks as consumption does not occur anymore in clandestine environments, rather Portugal’s decriminalization included public facilities for problematic substance consumers. Then, as consumers observe the decrease in risk, consumption increases. Finally, once the consumption level is close to the median lethal dose, the risk raises again. The long-term effect of this model suggests that drug-related death risk is independent of any legal framework change. We identify a parametrized equilibrium such that the long-term effect on drug-related deaths is zero. In the empirical part of the paper, we test the hypothesis of a nonlinear effect like the one described.

Additionally, we model the decision-making process of firms selling psychoactive substances. Our theoretical results suggest an increase in efforts to gain market share due to a sustained increase in consumption. As decriminalization leads to a potential increase in consumption, even
if the perceived risk by consumers decreases in the periods following the legal framework reform and the market in which transactions for substance remain illegal, the positive effect of decriminalization on violence could be explained by the use of coercive and violent mechanisms to gain and expand firms’ market share in an illegal market.

To develop a causal estimation of the effect of decriminalization on drug-related deaths and homicides we use data from the European Monitoring Center for Drugs and Drug Addiction (EMCDDA) and the World Bank. Drug-related death is defined as “an epidemiological indicator with two components at present: deaths directly caused by illegal drugs (drug-induced deaths) and mortality rates among problem drug users” (EMCDDA, 2020). Employing a difference-in-differences identification strategy we find: (i) decriminalization reduced drug-related deaths the three first periods after the reform, (ii) in the long-term, 16 years after decriminalization, we find null effects on drug-related deaths, and (iii) decriminalization increased homicides rate in a range of 28.7%-34.2%.

Lastly, we run placebo tests to demonstrate that our findings on drug-related deaths were not confounding with overall improvements in health conditions in Portugal. Therefore, we do not find effects of decriminalization on life expectancy nor on the supply of health facilities measured through hospital beds rate. Additionally, we prove that Portugal did not have an outlier trend in terms of mortality by cardiovascular disease, diabetes, cancer, and chronic respiratory disease in the years following decriminalization. This evidence puts forward our argument of the specific effect of decriminalization on drug-related deaths.

The central aspect of the empirical methodology is to guarantee two assumptions: (i) none of the countries in the sample received the treatment and (ii) the treatment effectively began in 2001. The first assumption is verified using several sources and showing time trends for European countries in the Methodology section (Bretteville-Jensen, 2006; TDPF, 2021; Woods, 2011). The second assumption is discussed and partially verified as decriminalization law entered into force in July 2001 through Law 30/2000. Previous works suggested that this change did not imply any factual change in the approach of Portugal towards illicit drug consumption as there was a lack of enforcement of drug consumption prior to 2001 (Laqueur, 2015). Nevertheless, drug use arrests and citations fell considerably between 2000 and 2001, the first year of the implementation of the regulation. Prior to this period, this variable increased until 1999 and remained constant between 1999 and 2000. Therefore, both methodological assumptions
potentially hold in this context enabling us to estimate unbiased causal effects of decriminalization.

Discussion around decriminalization ranges from philosophical criminology to economic mechanisms that affect drug consumption. Husak (2003) and Sher (2003) discuss the decision of a State on whether to punish a person for consumption of illicit drugs. The authors disagree as Husak (2003) argues that the State should protect individuals rather than punish them and that criminalization is counterproductive, while Sher (2003) defends criminalization as the harms of consumption of certain substances are large enough to justify this legislation. Furthermore, Bretteville-Jensen (2006) developed a theoretical model on the effect of decriminalization on drug prices through a systematic literature review and discusses if there is an optimal level of drug consumption. This literature review concludes there is no evidence for a price demand elasticity equivalent to zero and the potential risk of a positive effect of decriminalization on consumption, mediated by a decrease in prices. However, there is no consistent evidence on whether or not the price demand elasticity is below or above -1 (Bretteville-Jensen & Bjørn, 2003; Grossman & Chaloupka, 1998; Liu et al., 1999; Nisbet & Vakil, 1972; Silverman & Spruill, 1997).

Besides theoretical discussions, Vicknasingam et al. (2018), in a comprehensive literature review of cannabis decriminalization, did not find effects on age-onset nor prices. As well, several empirical articles estimate the effects of marijuana laws on adult and adolescent use, opioid prescriptions, alcohol consumption, and age onset. Consistently, these papers found increasing levels of consumption of marijuana and opioid prescriptions, but there is no evidence on problematic drug use (DiNardo & Lemieux, 2001; McMichael et al., 2020; Wen et al., 2015; Williams & Bretteville-Jensen, 2014). Additional to cannabis decriminalization, there is increasing evidence on deaths related to the opioid epidemic in the United States. Both, medical access to opioids and prescription drug monitoring programs increased drug-related deaths (Balestra et al., 2021; Kim, 2021; Powell et al., 2020). Hence, there is no evidence of interventions resulting in negative or null effects on drug-related deaths.

Moreover, there is an increasing literature on drug policy reform and criminality. Both in London and in the US, there is evidence of a reduction in criminal activity due to an eventual decriminalization of marihuana possession and medical marihuana laws, respectively (Adda et
al., 2014; Gavrilova et al., 2019). Moreover, the economic literature has broadly documented the unintended effects of supply-side interventions on violence (Werb et al., 2011).

For the Portuguese case, several empirical studies have explored the effects of decriminalization on multiple outcomes. In a descriptive analysis, Hughes & Stevens (2010, 2015) suggest that, after decriminalization, there were no changes in consumption trends compared to neighboring European countries. Felix et al. (2017) found null effects on drug-related deaths in the medium term and, from a criminal perspective, a reduction in cocaine seizures and drug-law offenses. Their study was limited to designing a synthetic control method until 2008 and did not include robust inference methodologies to interpret their findings. In this paper we go further estimating the effect in multiple time horizons which is a fundamental aspect in the substance regulation policy debate, we model consumers’ and firms’ behavior, we explore effects on violence-related deaths, and we employ recent statistical techniques to determine the robustness of our findings. Moreover, Felix & Portugal (2017) found null effects of decriminalization on opiates and cocaine prices ten years after decriminalization. Lastly, Goncalves et al. (2015) found a 12% and 18% reduction in social costs of decriminalization in the short and long-term, respectively.

The contribution of this paper is threefold. Firstly, we contribute to the theoretical literature on the potential effects of drug decriminalization as we build a theoretical dynamic model of the effects of decriminalization on consumers’ behavior and violence related to substance transactions. Second, we find evidence of the effect of the Portuguese decriminalization process— the strongest experience in this regard—on deaths related to drug use and homicides. Lastly, consistent with the theoretical model, we identify short-, middle-, and long-term effects of decriminalization on mortality outcomes. Therefore, this article contributes to building evidence around drugs consumption decriminalization and potential lessons for a worldwide discussion on the regulation of illicit substances.

The second section of this paper presents the institutional context of Portugal’s decriminalization process and the third develops the theoretical framework of the potential effects of decriminalization on drug-related deaths and homicides. Afterward, Section 4 presents the data employed to estimate the impact on drug-related deaths and homicides. Section 5 describes the difference-in-differences identification strategy employed in this paper. Then, in Section 6, we present the main findings and, lastly, Section 7 concludes discussing the results and the policy implications.
2. Institutional context of decriminalization

Portugal’s legal decision to decriminalize the consumption of every illicit substance was the result of a social and political process that beginning in the 1980s. During these years, Portugal reported one of the highest levels of overdoses and HIV cases in the world (The Guardian, 2017; Domoslawski, 2011). HIV infection rate in Portugal was the highest rate among European countries during this period. After a United Nations summit, the social crisis of drug consumption and HIV infections was faced politically by the Portuguese Government.

In Portugal, anecdotally, two doctors from the south of the country opened consumption centers by demand of the Ministry of Health in order to control and treat problematic drug users since 1988. These functionaries became drug consumption experts and led the creation of a Commission to face the increasing problem of drug consumption at the national level. From a legal stand, Rui Pereira, constitutional judge, was the first public servant to propose the decriminalization of illicit drug consumption. By 1999, the Commission suggested the decriminalization of illicit drug consumption to face the upsurge of this phenomenon from a public health perspective rather than a criminal one. In 2000, the Minister’s Cabinet and the National Congress approved the decriminalization of consumption of illicit drugs, and it entered into force in July 2001. Until this year, even if the Legislation differentiated between crimes of traffic and crimes of use, drug use was punished with up to 3 months imprisonment and for possession, the penalty could go to 1 year of prison. Hence, the regulatory change is not comparable to any other country in Europe (Bretteville-Jensen, 2006).

Portugal became the first country to decriminalize every illicit drug as the legal framework did not differentiate between hard and soft substances. The main pillars of Portuguese drug consumption decriminalization are (i) no differentiation of soft and hard drugs, however, there are unhealthy relationships with drugs; (ii) unhealthy relationships’ consequences are not limited to consumers, and (iii) it is unviable to eradicate the use of illicit drugs. The approach has been one of public health in which the investment was oriented towards prevention, treatment, arms reduction, and social integration (Russoniello, 2012; TDPF, 2021). This legal change enabled institutions to face consumption in this manner and to orient their efforts to reduce the negative consequences of drug consumption. Portugal’s experience has several lessons for other countries and for the global discussion about drugs decriminalization (Woods, 2011).
3. Theoretical decriminalization framework

Theoretically, decriminalization could have effects in different directions on drug-related deaths and violence. On the one hand, decriminalization can increase consumption and problematic drug use by reducing consumption costs as it is less risky and operatively less costly to consume (Corredor-Waldron & Currie, 2022; Gallet, 2013). On the other hand, decriminalization enables an institutional framework to treat consumption such as consumption centers, treatment, among others, that could reduce the likelihood of problematic drug use and drug-related deaths (Rigoni et al., 2018). However, these effects may differ depending on the time horizon. In terms of the potential negative effects of decriminalization on drug-related deaths, there are fixed costs at the beginning of the implementation of decriminalization. The implementation of a public health approach requires human capital formation, changes in organizational and cultural structures, and the learning of new forms of relationship between consumers and the State. In this context, there is a learning-by-doing process of formal institutions to treat consumption and consumers.

In terms of violence, decriminalization could affect current dynamics in opposing directions as well. Part of the war against drugs is sustained on the hypothesis of reducing the revenue of illegal armed groups in order to control their capabilities to exert violence (Werb et al., 2011). Decriminalization could increase consumption, as previously mentioned, and increase the marginal benefits of trafficking organizations leading to higher incentives for violent actions between gangs (Blumstein, 1995; Brownstein et al., 2000; Donohue & Levitt, 1998; Goldstein et al., 1989; Guerrero, 1998; Rainbow, 2010). The mechanisms to gain market share are violent as illicit markets are characterized by a lack of legal resource to solve conflicts and the State do not solve discrepancies, protect property rights nor ensure the accomplishment of contracts (Andreas & Wallman, 2009; Castillo et al., 2020; Miron & Zwiebel, 1995; Prieger & Kulick, 2015). However, decriminalization could also derive in a more efficient allocation of police and judiciary resources what could reduce criminal activity as proved with marihuana laws and its decriminalization (Adda et al., 2014; Gavrilova et al., 2019).

These theoretical predictions are developed through an intertemporal model of drug consumption in which the consumer derives utility from a normal good, consumption of substances and the risk associated with the latest consumption. The relevant variable to introduce the legal framework reform in the instantaneous utility function is the risk of
consuming substances as it depends on the health infrastructure to treat drug consumption and it is unobserved by the consumer.

Consumers

The instantaneous utility of the consumer is given by:

\[ U_t = u(c_t) + v(d_t) - E(\mu_t)d_t \]  \hspace{1cm} (1)\(^5\)

Where \( c_t \) is the consumption of a standard consumption good, \( d_t \) is the consumption of drugs and \( \mu_t \) can be understood as the probability of a drug-related death or, in general, the negative effect of a unit of drugs\(^6\).

\( u(c_t) \) is a standard utility function derived from the consumption of the standard good, where \( u_{c_t}(c_t) > 0 \) and \( u_{c_tc_t}(c_t) \leq 0 \).

\( v(d_t) \) is the utility derived from the consumption of drugs, \( v_{d_t}(.) > 0 \).

Information is imperfect in two dimensions:

1. \( \mu_t \) is not perfectly observed by the consumer (Kilmer et al., 2007; Shewan et al., 2000). We assume that \( \mu_t \) is observed at \( t+1 \) and consumers actualize beliefs with the following function: \( E(\mu_t) = (\mu_{t-1}) \). Where \( E(\mu_t) \) is the expected value of \( \mu_t \).

2. \( \mu_t \) is an increasing function (truncated) of the quantity of \( d_t \). There exists a \( \tilde{d} \) such that, holding the rest constant, if \( d_t < \tilde{d} \) then \( \mu_t \) does not depend on \( d_t \) and if \( d_t \geq \tilde{d} \) then \( \mu_t \) is an increasing function of \( d_t \). We can rationalize \( \tilde{d} \) with the lethal median dose (Akhila et al., 2007).

We normalize the price of the consumption good to one so the consumption good is the numeraire in the model and the budget constraint of the consumer is \( p_t d_t + c_t \leq y_t \) where \( y_t \) is the consumer’s income.

Once the consumer maximizes (1) subject to the budget constraint, the first order condition is the following:

\(^5\) This utility function is a specific case of the one introduced by Becker et al. (1991).

\(^6\) For simplicity, we only model the utility of drug consumers. However, the results are robust to the inclusion of other type of agents.
\[ v_{d_t}(.) = p_t u_{c_t}(\epsilon_t) + E(\mu_t) \]  

(2)

Given the assumptions about the utility function, equation 2 implies that \( d_t \) depends negatively on \( p_t \) and \( E(\mu_t) \), and positively on \( c_t \).

Now, consider an initial situation where \( d_t < \bar{d} \) and \( E(\mu_t) = \mu_t \). Given the income level of the consumer, there is a persistent equilibrium for \( d \) and \( \mu \). Finally, assume that, at time \( T \), there is decriminalization, hence an exogenous decrease in \( \mu_t \).

The decrease in \( \mu_t \) can be explained by (i) better quality of drugs, (ii) safe consumption practices, (iii) more access to health services, among others.

A lower \( \mu_t \) directly implies a reduction in deaths. However, it also generates an increase in consumption in \( t + 1 \) because \( E(\mu_{t+1}) \) is an increasing function of \( \mu_t \). Therefore, as \( \mu_t \) decreases \( d_t \) grows. Notice however that there is a double causality between \( \mu_t \) and \( d_t \). As long as \( d_t < \bar{d} \), an increase in drug consumption does not affect \( \mu_t \). Once \( d_t \) reaches the critical level, any increase in consumption leads to an increase in \( \mu_t \) and, therefore, an increase in the number of deaths. In summary, the first effect is a reduction in risk, but this reduction stimulates consumption and the increase in consumption increases the death risk.

Producers: perfect information

Total consumption of drugs is given by \( D_t = \sum_{i=1}^{N_t} d_{i,t} \) where \( d_{i,t} \) is the consumption of agent \( i \) at time \( t \) and \( N \) is the total number of consumers. In the domestic market, there is a finite number of firms, each one with a share \( \epsilon_j \) of the market. Therefore, the income of firm \( j \) at time \( t \) is given by \( \epsilon_{j,t} p_t d_t \), where \( p_t \) is the unitary price for drugs.

Domestic firms buy drugs in the international market and sell them in the domestic market. We assume that these firms are small, so they take wholesale prices, \( \gamma_t \), as given. However, in the domestic market firms have market power and they set domestic prices adding a mark up to the international price (Prieger & Kulick, 2015). Therefore \( p_t = \gamma_t (1 + \mu u) \) and the income of firm \( j \) at time \( t \) is given by \( \epsilon_{j,t} p_t (1 + \mu u) d_t \).

Finally, in order to keep the market share, firms need to invest in preemptive strategies. Hence, the profits made by a firm are given by:
\[ \Pi_{j,t} = \epsilon_{j,t} \gamma_t (1 + mu) d_t - g(\epsilon_{j,t}) \]  

(3)

where the cost \( g(\epsilon_{j,t}) \) is increasing in the share of the market and the marginal cost is also increasing, namely, \( g'(\epsilon_{j,t}) > 0 \) and \( g''(\epsilon_{j,t}) > 0 \). These assumptions derive from the illegality of the business we are modelling, so the strategy to maintain market share includes having armed people, controlling the territory, among others, as there are not legal means to expand market power nor to solve conflicts in this illegal economy (Andreas & Wallman, 2009; Castillo et al., 2020; Miron & Zwiebel, 1995; Prieger & Kulick, 2015). Likewise, the strategy to increase market share includes attacks on competitors and gangs that defend the market share of other firms. In other words, efforts to increase market power are associated with increases in violence.

Under these circumstances the firm chooses \( \epsilon_{j,t} \) in order to maximize profits, \( \max_{\epsilon_{j,t}} \Pi_{j,t} \) so

\[ g'(\epsilon_{j,t}) = \gamma_t (1 + mu) d_t \]  

(4)

In other words, the higher the aggregate consumption level, the higher the incentives to increase the market share.

**Disinvesting costs and noisy consumption**

Suppose now that it is difficult for firms to recognize permanent increases in consumption because it has a random component with zero mean, and constant and large variance. Investments in market power, on the other hand, are hardly reversible since they involve the purchase of weapons and the hiring of individuals willing to do criminal work with whom, in addition, part of the firm's information must be shared. Under these circumstances, no firm will invest in increasing market share unless it is certain that there is a permanent increase in aggregate consumption.

To deal with this problem, firms adjust their decisions depending on the average aggregate consumption in \( T \) periods, instead of contemporary reactions, and react with a one-period lag:

\[ \bar{D}_t = \frac{1}{T} \sum_{v=t-T}^{t} D_v \]  

(5)
\[ g'(\epsilon_{j,t}) = \gamma_t (1 + mu) \bar{D}_t \]  

(4')

In these circumstances, a permanent increase in aggregate consumption does not have an immediate effect on the levels of violence, but rather a lagged effect that ends up being consolidated after \( T \) periods.

\textit{A functional form example}

Consider the following market power cost function

\[ g(\epsilon_{j,t}) = \frac{1}{2} (\epsilon_{j,t})^2 \]

\[ \epsilon_{j,t}^* = \gamma_t (1 + mu) \bar{D}_t \]  

(4'')

\textbf{Proposition 1: If there is permanent increase in} \( \bar{D} \) \textbf{at time} \( \bar{t} \), then

(i) \( \epsilon_{j,\bar{t}} = \epsilon_{j,\bar{t}-1} \)

(ii) \( \epsilon_{j,\bar{t}+T} > \epsilon_{j,\bar{t}-1} \)

This result suggests that a permanent increase in average drug consumption leads to a sustained increase in efforts to expand the market share of each firm \( j \) in order to increase their profit. Hence, as these efforts occur in a black and illegal markets they must be done through violent means, leading to a sustained increase in violence and homicides. Now, considering the functional form example for the consumption side of the market, we have that:

\[ U_t = \log(c_t) + \varnothing \log(d_t) - E(\mu_t) d_t \]  

(1')

On the one hand, we assume that \( \mu_t \) has an exogenous component (constant) \( \mu_0 \), but is also affected by \( \vartheta_t \), the public supply of health services, and the consumption level. On the other hand, once \( d_t \) reaches the critical level any increase in consumption leads to an increase in \( \mu_t \). Therefore, the functional form of \( \mu_t \) is the following

\[ \mu_t = \begin{cases} 
\mu_0 (1 - \vartheta_t) & \text{if } d_t < \bar{d} \\
\mu_0 (1 - \vartheta_t) + \xi \log(d_t) & \text{if } d_t \geq \bar{d} 
\end{cases} \]  

(6)

Regarding expectations we assume that:

\[ E(\mu_t) = \mu_{t-1} \]  

(7)

Therefore, equation 2 becomes

\[ \frac{1}{d_t} \varnothing = p \frac{1}{\epsilon_t} + E(\mu_t) \] so
\[ d_t = \frac{\emptyset}{P_t + E(\mu_t)} \]  \hspace{1cm} (2')

We assume that consumers do not internalize the effect of \( d_t \) on \( \mu_t \), they just observe \( \mu_{t-1} \) and update \( E(\mu_t) \).

Note that \( d_t \) is an increasing function of \( \vartheta_t \). For this reason, while decriminalization reduces consumption risks, it also increases consumption levels. Hereby, as decriminalization increase consumption levels, it creates incentives to expand market share of firms leading to a potential expansion of the use of violence after decriminalization.

**Proposition 2:** In equilibrium, \( d_t \) is an increasing function of \( \vartheta_{t-1} \).

**Proof:**

(i) From equation 3 it follows that \( \frac{\partial \mu_t}{\partial \vartheta_t} < 0 \)

(ii) From equation 2' and 4 it follows that \( \frac{\partial d_t}{\partial E(\mu_t)} < 0 \) and \( \frac{\partial E(\mu_t)}{\partial \mu_{t-1}} > 0 \)

(iii) \( \frac{\partial d_t}{\partial \vartheta_{t-1}} = \frac{\partial d_t}{\partial E(\mu_t)} \frac{\partial E(\mu_t)}{\partial \mu_{t-1}} \frac{\partial \mu_{t-1}}{\partial \vartheta_{t-1}} \)

From (i), (ii) and (iii) it follows that \( \frac{\partial d_t}{\partial \vartheta_t} > 0 \)

**Corollary 1:** If \( d_t \geq \tilde{d} \) then the initial effect that an increase in \( \vartheta_t \) has on \( \mu_t \) is mitigated through the effect that an increase in \( d_{t+1} \) has on \( \mu_{t+1} \).

Corollary 1 follows directly from equation (3) and proposition 1. An increase in \( \vartheta_t \) has a negative direct effect on \( \mu_t \) which in turn generates a reduction \( E(\mu_{t+1}) \) and an increase in \( d_{t+1} \). However, since \( d_{t+1} \geq \tilde{d} \), the increase in \( d_{t+1} \) generates an increase in \( \mu_{t+1} \).

Expectations about the risk of consumption do not respond immediately to actual changes in risk and, for this reason, consumption grows slowly. However, if the decrease in risk is persistent, expectations converge towards the actual risk, and risk perception decreases. This results in an increase in consumption. Once consumption is equal or higher to the critical level, risk and consumption grow together.

¿What effect prevails in the long run?
In the following lines, we characterize the long-run equilibrium for a certain range of parameters and the conditions under which the long-run effect of decriminalization is null.

**Long run**

In the long run, all the parameters of the model are stable, so all variables converge towards a steady state. From equation 6, expectations of $\mu_t$ converge to its actual value in the long run.

$$E(\mu_{LR}) = \mu_{LR}$$  \hspace{1cm} (8)

The subindex LR accounts for long run.

From (2') and (8)

$$\mu_{LR} = \frac{1}{d_{LR}} \phi - p \frac{1}{c} \text{ or } d_{LR} = \frac{\phi}{\mu_{RL} + p \frac{1}{c}}$$  \hspace{1cm} (9)

If $\mu_{LR} = \mu_0$ then from equation (9),

$$\mu_0 = \frac{1}{d_{LR}} \phi - p \frac{1}{c} \text{ or } d_{LR} = \frac{\phi}{\mu_0 + p \frac{1}{c}}$$  \hspace{1cm} (10)

Therefore, given $p$ and $c$ there is one value of $d_{LR}$ such that $\mu_{LR} = \mu_0$.

From equations 6 and 7, if long run consumption is higher than $\tilde{d}$ and $\mu_{LR} = \mu_0$ then

$$\mu_0 = \mu_{LR} = \xi \log \left( d_{LR} \right)$$  \hspace{1cm} (11)

From (10) and (11)

$$\mu_0 = \xi \log \left( \frac{\phi}{\mu_0 + p \frac{1}{c}} \right)$$  \hspace{1cm} (12)

**Proposition 3:** If $\left( \frac{p}{c} + \mu_0 \right) e^{\frac{1}{\xi}} > \phi > p \frac{1}{c} + \mu_0$ then there exist a $\bar{\mu}_0$ such that $\bar{\mu}_0 = \xi \log \left( \frac{\phi}{\mu_0 + p \frac{1}{c}} \right)$

**Proof:**
(i) The derivative of the left-hand side of equation 12 with respect to $\mu_0$ is positive, while the derivative of the right-hand side is negative.

(ii) If $p \frac{1}{c} + \mu_0 < \emptyset$ and $\mu_0 = 0$ then $\mu_0 < \xi \log \left( \frac{\emptyset}{\mu_0 + p_1 c} \right)$.

(iii) If $\left( p \frac{1}{c} + \mu_0 \right) e^{\xi} > \emptyset$ then $1 > \xi \log \left( \frac{\emptyset}{\mu_0 + p_1 c} \right)$ and $1 > \xi \log \left( \frac{\emptyset}{\mu_0 + p_1 c} \right)$ so if $\mu_0 = 1$ then

$$\mu_0 > \xi \log \left( \frac{\emptyset}{1 + p_1 c} \right)$$

(iv) $\emptyset \geq p \frac{1}{c} + \mu_0$ is a necessary condition to guarantee $\log \left( \frac{\emptyset}{\mu_0 + p_1 c} \right) \geq 0$

From i, ii and iii it follows that there exists a $\bar{\mu}_0$ such that $\bar{\mu}_0 = \xi \log \left( \frac{\emptyset}{\mu_0 + p_1 c} \right)$

In Appendix A.1, we analyze the cases where the conditions of proposition 2 do not hold. The main results of the consumption model are summarized in propositions 1 and 2. These results suggest that, with a certain range of parameters, in the long run, the probability of overdose or death due to drug consumption is independent of decriminalization.

Hence, through this theoretical model we were able to characterize a non-linear association between drug consumption decriminalization and the observed risk of consuming these substances. Moreover, the non-linearity of the effects explains the negative short-term effect on drug-related deaths and a potential null effect on the long-term or several periods after decriminalization occurred. Additionally, we proved that firms related to the sell and trafficking of psychoactive substances have incentives to increase their market share following a sustained increase in the average consumption. Hence, in illegal markets, violence and repressive power are the tools employed to expand market shares. Therefore, the potential increase in consumption of substances could explain the increase in violence after decriminalization as these transactions remain a question of organized crime. In our empirical approach we demonstrate that a range of parameters to sustain null effects of decriminalization on drug-related deaths in the long term exist and that decriminalization increase homicides.
4. Data

The main variables of interest, drug-related deaths and homicides rate by 100,000 inhabitants, are reported by the EMCDDA which is the formal European institution responsible to monitor the drugs situation in Europe and the World Bank, respectively. From these sources, it is possible to build an annual panel dataset at the country level from 1990 to 2017.

In terms of the homicides rate outcome there are no limitations, and the panel data is consistent for the period under study. However, regarding the drug-related deaths data, one limitation is the different series available depending on the year of publication of the data. The first series reports information from 1990 to 2007, the second reports data from 2008 to 2016, and the latest from 1999 to 2017. One of the purposes of these updates in the methodology was to systematically improve the comparability of the data between countries.

First of all, it is worth mentioning that we acknowledge the limitations that multiple series and measures could draw for our empirical analysis. If the series do not represent the same time trend within countries it will not be possible to employ these data. However, if there is only a difference in levels, then it is possible to employ different series, merge them and estimate the effect of decriminalization. Moreover, as the identification strategy is a difference-in-difference model, we are exploiting the within variation of the outcome by unit and we are controlling for unobservable time-invariant characteristics for each country that could control for potential threats of employing different series. Hence, an empirical alternative to prove the fulfillment of this assumption is correlating the data in the periods in which they overlap. If the correlation is strong and significant, we can ensure that the differences between the data is in levels rather than variations within a country and we can merge the series, adjusting by levels, to estimate an unbiased effect.

We employ the 1990-2007 and 1999-2017 series and for the 1999-2007 period there are 0.94 correlated as depicted in Figure 1, and the correlation is statistically significant at the 99% level. In Appendix A.2. we present the correlation of the data for each period to show that the overall correlation between series is independent of the year in which drug-related deaths were measured. Secondly, we adjust the data in 2007 to avoid a potential confounding effect between the treatment and the adjustment of the data. Hence, in order to create a panel from 1990 to
2017 we merge the most recent and the oldest data reported by EMCDDA. The adjustment consists on rescaling the levels reported in each series.

Figure 1. Correlation between drug-related deaths measures

On top of drug-related deaths and homicides, we collect variables that are known determinants of the outcomes based on an extensive literature review to control for specific time-trends of these variables in the model. We include estimated drug retail prices, income per capita, infant mortality, share of male population, inequality, life expectancy, active armed forces personnel and alcohol consumption (Fisher et al., 2004; Galea et al., 2003; Kandel & Logan, 1984; Katz et al., 2011; King et al., 2014; Marcelli, 2001; Pear et al., 2018). In Table 1, we present each variable employed in the econometric approach, its corresponding source of information, and descriptive statistics of the variables the year before decriminalization occurred. These descriptive statistics, especially for the outcomes and excluding Portugal, enables to compute the magnitude of the estimated effects.

Table 1. Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drug-related deaths (log)</td>
<td>EMCDDA</td>
<td>5.708</td>
<td>1.228</td>
</tr>
<tr>
<td>Homicides rate (by 100,000 inhabitants)</td>
<td>World Bank</td>
<td>1.392</td>
<td>0.507</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male population (%)</td>
<td>World Bank</td>
<td>48.995</td>
<td>0.479</td>
</tr>
<tr>
<td>GDP per capita (log)</td>
<td>World Bank</td>
<td>10.065</td>
<td>0.391</td>
</tr>
<tr>
<td>Infant mortality rate (by 1,000 births)</td>
<td>World Bank</td>
<td>4.567</td>
<td>0.700</td>
</tr>
<tr>
<td>Pure alcohol consumption (yearly liters per person)</td>
<td>WHO</td>
<td>10.716</td>
<td>2.526</td>
</tr>
<tr>
<td>Income inequality (GINI)</td>
<td>European Union</td>
<td>0.338</td>
<td>0.32</td>
</tr>
</tbody>
</table>
5. Methodological approach

Comparing Portugal with the rest of European countries after decriminalization is not adequate as there could be confounding factors explaining drug-related deaths and homicides different from the drug consumption legal framework. Hence, to estimate the effect of Portuguese decriminalization on drug-related deaths and homicides we employ a difference-in-differences identification strategy. The effect is computed through a model specified as follows:

\[ y_{c,t} = \mu_c + \mu_t + \delta_{\text{Portugal}_c} * Post_t + \beta X_{c,2000} + \epsilon_{c,t} \]  

(13)

where \( y_{c,t} \) is the logarithm of drug-related deaths and the homicides rate by 100,000 inhabitants; \( \mu_c \) and \( \mu_t \) are country and year-fixed effects, respectively; \( \text{Portugal}_c \) is a dummy variable equals 1 if the observation corresponds to Portugal; \( \text{Post}_t \) is a dummy variable equals 1 from 2001 onwards and \( X_{c,2000} \) is a matrix of drug-related deaths and homicides determinants prior 2001 interacted with year-fixed effects. In the model of drug-related deaths, the matrix included cocaine retail price, heroin retail price, income inequality measures, pure alcohol consumption, life expectancy, male population, GDP per capita and infant mortality rate. In the homicides model, the matrix included cocaine retail price, income inequality measures, pure alcohol consumption, male population, active armed forces personnel rate and GDP per capita. The error term is \( \epsilon_{c,t} \).

Mechanically, standard errors in difference-in-differences approaches are serially correlated within aggregation units (Bertrand et al., 2004). A potential method to adjust standard errors is with cluster-robust standard errors to approximate an unbiased estimate. However, this method requires a large number of clusters, and the asymptotic validity does not hold if this assumption is not fulfilled. Therefore, we use a wild clustered bootstrap method to correct for the serial correlation of the errors with a small number of clusters (Canay et al., 2021).

Additionally, the central aspect of the difference-in-differences methodology is to approximate the fulfillment of the parallel trends’ assumption. This methodology allows for differences
between treated and untreated units, but the difference must be time-invariant. Usually, a leads and lags model tests for anticipatory effects of the treatment to prove the attribution of the effect to the treatment. However, there is an inference limitation by estimating a leads and lags model as the effect will be computed with a unique observation rather than an average of treated units in each period. Therefore, the leads and lags model will be developed, with the previous caveat in mind, and will be presented in the Results section of the paper following this specification:

\[ y_{ct} = \mu_c + \mu_t + \sum_{g=1990}^{1999} \delta_{g} \text{Portugal}_c \ast \text{Year}_g + \sum_{g=2001}^{2017} \delta_{g} \text{Portugal}_c \ast \text{Year}_g + \beta X_{c,2000} + \varepsilon_{ct} \]  \hspace{1cm} (14)

The definitions of the variables in Equation (14) are the same as in Equation (13), except for \( \text{Year}_g \) accounting for a dummy variable equals 1 for the corresponding \( g \) year of the sum. The same discussion on the standard errors applies in this dynamic specification.

Methodologically, it is required that none of the countries in the sample received the treatment after 2001. Bretteville-Jensen (2006) suggests that Portugal is the only country with legal changes of such proportions and European countries were unaffected by this legal change. Additionally, in Table 2 we present the characteristics of the legal framework of illicit drugs consumption in each of the countries included in the sample and the changes that occurred after 2001. The particularity of the Portuguese reform in 2001 is that it became the only country where it is not possible to imprison a person due to drugs possession and where there is no differentiation between drug types.

An additional concern, especially for long-term analysis is that the counterfactual remains an ideal comparison group for a long period of time. Even if it is not possible to empirically guarantee this assumption as there could be specific changes in other countries affecting drug-related deaths and violence, to the best of our knowledge, between 2001 and 2017 there were no legal framework reforms in these countries aiming at decriminalizing drug consumption. In the last column of Table 2, we show that there were no changes aiming to the imprisonment for possession or the differentiation of drugs in any country after 2001. Hence the methodological assumptions are likely to be fulfilled.
Table 2. Drug consumption legal framework in European countries

<table>
<thead>
<tr>
<th></th>
<th>Differentiation between possession and traffic</th>
<th>Possible to imprisonment punishments due to possession</th>
<th>Possession considered as a drug crime</th>
<th>Drug type differentiation in penalties</th>
<th>Changes after 2001 related with drug use and possession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>2003: Distinction between possession of cannabis for personal use and all other types of offences.</td>
</tr>
<tr>
<td>Belgium</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Luxembourg</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

In addition to ensuring no changes in legal frameworks in European countries since 2001, Figure 2 suggests null spillovers in other European countries in drug-related deaths after Portuguese decriminalization. First, in neighboring countries such as Spain, France and Italy, where we can expect geographic spillovers, the trends in drug-related deaths do not suggest spillovers around the 2001 cutoff. Moreover, we plotted the Netherlands as it has a more flexible regulation towards cannabis consumption and possession, and we could expect a dynamic response in this country towards the change in the regulation in Portugal. Around the period of the decriminalization, we do not evidence any spillover in the drug-related deaths trend in the Netherlands. Additionally, there is a smooth evolution in drug-related trends in other European countries in the vicinity of 2001. Hence, this evidence does not suggest spillover effects of
Portuguese decriminalization on other countries evolution of drug-related deaths, reassuring the fulfillment of the assumption as Portugal was the only treated unit.

Figure 2. European countries drug-related deaths trends

![Figure 2](image)

Figure 3 plots the evolution of homicides rate in Portugal, neighboring countries and the other European countries included in the sample. After 2001, year of the reform, the increase of homicides rate in Portugal is straightforward. Moreover, in its neighbors and the Netherlands, we do not observe changes around the cutoff line.

Figure 3. European countries homicides rate trends

![Figure 3](image)

6. Results

This section is organized in three subsections to present our findings: i) results corresponding to drug-related deaths, ii) results corresponding to homicides rate, and iii) placebo tests.

6.1. Drug-related deaths
Table 3 presents the findings for the short, mid- and long-term. These models suggest a negative but insignificant 27.5% effect of drugs consumption decriminalization on drug-related deaths on the short-term. The lack of statistical power in these models is explained by the reduced number of observations, hence, we focus on the magnitude and direction of the effects. In the medium-term, we estimated a negative insignificant 24% effect. In the long-term, these results suggest an average null effect of decriminalization on drug-related deaths. Including all the characteristics interacted with time-fixed effects, the estimate suggests a positive 7% insignificant effect. As developed in the methodological section, we present several methods to compute the standard error of the estimate. We bootstrapped the estimate by country and by country-year, and we tested if our results are consistent if we restrict the distribution of the bootstrap to zero or if we do not. However, we only report results for country level bootstraps.

Table 3. Decriminalization effects on drug-related deaths

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Portugal short-term</th>
<th>Portugal medium-term</th>
<th>Portugal long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td>-0.275</td>
<td>-0.24</td>
<td>0.07</td>
</tr>
<tr>
<td>Cluster-robust SE</td>
<td>0.217</td>
<td>0.323</td>
<td>0.416</td>
</tr>
<tr>
<td>t-statistic</td>
<td>-1.27</td>
<td>-0.74</td>
<td>0.17</td>
</tr>
<tr>
<td>N</td>
<td>225</td>
<td>315</td>
<td>420</td>
</tr>
<tr>
<td>P values and confidence intervals</td>
<td>P values</td>
<td>Confidence interval</td>
<td>P values</td>
</tr>
<tr>
<td>Bootstrap by country, restricted</td>
<td>0.841</td>
<td>[-3.019; 1.802]</td>
<td>0.742</td>
</tr>
<tr>
<td>Bootstrap by country, unrestricted</td>
<td>0.833</td>
<td>[-0.617; 0.756]</td>
<td>0.713</td>
</tr>
</tbody>
</table>

Note: This table presents the effects of drug consumption decriminalization in Portugal in the short-, mid-, and long-term on drug-related deaths. Additionally, we present two methodologies to compute the standard errors as the number of clusters is limited in this setting. *** p<0.01, ** p<0.05, * p<0.1

Therefore, employing a static and parametric difference-in-difference method to estimate the effects of drugs consumption decriminalization we do not find significant effects. These results could be mainly explained by the lack of statistical power due to the reduced size of the sample as we account for 225, 315 and 420 observations for the short-, medium-, and long-term, respectively. However, in the most robust model, including all the pre-treatment characteristics the sign of the estimates and their magnitude are consistent with the non-linear effects of the

---

7 We ran the same models bootstrapping the standard errors by country-year level and found consistent results. Results are available upon request.
theoretical model as we found negative effects for the short- and medium-term, and null effects for the long-run, at least for the first 16 years after decriminalization.

These results suggest a long-term inelastic response of drug-related deaths to consumption legal framework reform in Portugal. Our findings outstand from other interventions oriented to impact overdoses and drug-related deaths. For example, Balestra et al. (2021) estimated a null effect of a monitoring program of opioid prescriptions on overdoses in the United States because overdoses due to heroin and fully synthetic opioids increased by 14%. Kim (2021) suggested a 0.9 heroin deaths per 100,000 inhabitants increase due to prescription drug monitoring programs. Therefore, the authors proved a substitution effect to illegal substances explained by these supply-side interventions. Lastly, Powell et al. (2020) proved a 0.71 opioid deaths elasticity of opioid medical supply. Hence, this empirical evidence in the US suggests a consistent increase in deaths due to opioid consumption—both legally and illegally—as a response to supply-side interventions.

To explore the dynamic effect in this difference-in-differences framework and to approach the fulfillment of the identification assumption, we estimate Equation (13). We proceed in the same way as for the static model bootstrapping the estimates. Consistent with the theoretical model, these results suggest a negative and significant short-term effect of decriminalization on drug-related deaths and a null effect in the long term. In most of the estimation methods of the standard errors, the effects corresponding to the first periods after decriminalization are negative and statistically significant. Moreover, from these dynamic models it is straightforward the convergence of the effect to zero in the long-term. Additionally, these results suggest the potential fulfillment of the parallel trends assumption as, independently of the bootstrapping method, there are no statistically significant effects 6 years before decriminalization took place.

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8 We ran the same models bootstrapping the standard errors by country-year level and found consistent results. Results are available upon request.
Panel 1. Dynamic difference-in-difference effects by bootstrapping method

Note: These graphs present the dynamic effect of drug consumption decriminalization on drug-related deaths. The point estimates are the same in every graph, what varies is the standard errors as we employed two bootstrapping methods as the number of clusters is limited in this setting. The confidence intervals of each estimate correspond to 95%.

6.2. Homicides

In terms of homicides, the results suggest aggregate null effects in the short-term. However, in the medium- and long-term, the reform increased homicides rate by 0.405 and 0.482, respectively. In relative terms to the pre-treatment mean, these effects represent a 28.7% and a 34.2% increase in homicides rate by time horizon. Following our methodological approach to estimate the standard errors, these effects are statistically significant employing cluster robust standard errors and bootstrapping the estimate at the country level without restricting the distribution of the bootstrap.

Table 4. Effects of decriminalization on homicides rate

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Portugal short-term</th>
<th>Portugal medium-term</th>
<th>Portugal long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td>0.155</td>
<td>0.405</td>
<td>0.482</td>
</tr>
<tr>
<td>Cluster-robust SE</td>
<td>0.321</td>
<td>0.262</td>
<td>0.242</td>
</tr>
<tr>
<td>t-statistic</td>
<td>0.48</td>
<td>1.55</td>
<td>1.99*</td>
</tr>
<tr>
<td>N</td>
<td>219</td>
<td>309</td>
<td>414</td>
</tr>
<tr>
<td>Pre-treatment mean</td>
<td>1.411</td>
<td>1.411</td>
<td>1.411</td>
</tr>
<tr>
<td>P values and confidence intervals</td>
<td>P values</td>
<td>Confidence interval</td>
<td>P values</td>
</tr>
<tr>
<td>Bootstrap by country, restricted</td>
<td>0.620</td>
<td>[-1.358; 1.423]</td>
<td>0.228</td>
</tr>
<tr>
<td>Bootstrap by country, unrestricted</td>
<td>0.609</td>
<td>[-0.301; 0.611]</td>
<td>0.047**</td>
</tr>
</tbody>
</table>

Note: This table presents the effects of drug consumption decriminalization in Portugal in the short-, mid-, and long-term on homicides rate. Additionally, we present two methodologies to compute the standard errors as the number of clusters is limited in this setting. *** p<0.01, ** p<0.05, * p<0.1
These results contradict the hypothesis of a more efficient allocation of police and judiciary resources after decriminalization as we found increases in criminal activity in the middle- and long-term (Adda et al., 2014; Gavrilova et al., 2019). Hence, our results support the idea of a market power mechanism consistent with our theoretical hypothesis (Blumstein, 1995; Brownstein et al., 2000; Donohue & Levitt, 1998; Goldstein et al., 1989; Guerrero, 1998; Rainbow, 2010). As the market in which substance transaction remained illegal, the methods employed by gangs and trafficking organization are violent and coercive leading to an increase in violence as the potential benefits of higher consumption incentivize these actors to expand their market share (Goldstein, 1985; Rainbow, 2010). However, our results are not generalizable to a context in which policy reforms exceeds decriminalization and focuses on the regulation of the production of these substances.

Regarding the dynamic model, from Panel 2 it is straightforward that we are able to prove no pre-treatment effects. Additionally, employing the cluster robust and unrestricted bootstrapping standard errors, we found positive and statistically significant effects of decriminalization on homicides rates. There results are consistent with our theoretical predictions as the model developed in section 2 suggested an increase in consumption in the short-term that could lead to an increase in transactions in the black market of illicit substances, leading to lagged violent actions of gangs to expand their market power.

Panel 2. Dynamic effects of drug consumption decriminalization on homicides rate

![Graphs showing dynamic effects of drug consumption decriminalization on hospital beds rate.](image)

Note: These graphs present the dynamic effect of drug consumption decriminalization on hospital beds rate. The point estimates are the same in every graph, what varies is the standard errors as we employed two bootstrapping methods as the number of cluster is limited in this setting. The confidence intervals of each estimate correspond to 95%.

6.3. Placebo tests

A potential concern about the short-term effect on drug-related deaths could be that the effect is confounding with a general improvement in health conditions rather than a specific effect of drug consumption decriminalization. Hence, we tested whether or not decriminalization had
short-term effects on life expectancy, the supply of health services and, descriptively, on mortality rate by other diseases after drugs consumption decriminalization.

Employing the difference-in-differences identification strategy to estimate the effects of decriminalization on life expectancy and estimating the effects by time-horizon we found that there are any statistically significant effects when bootstrapping the standard errors. However, for the short-term, period in which we are particularly interested as the purpose of the paper is to prove specific effects on drug-related deaths instead of a general improvement of health conditions, we found a positive significant effect at the 90% of confidence when bootstrapping by country and not restricting the null hypothesis. Hence, we ran the leads and lags model to test whether or not the effects in which we found negative impacts on drug-related deaths correspond to the same periods in which we found positive effects on life expectancy.

Table 5. Effects of decriminalization on life expectancy

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Portugal short-term</th>
<th>Portugal medium-term</th>
<th>Portugal long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td>0.005</td>
<td>0.006</td>
<td>0.013</td>
</tr>
<tr>
<td>Cluster-robust SE</td>
<td>0.002</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>t-statistic</td>
<td>2.27**</td>
<td>2.43**</td>
<td>4.01***</td>
</tr>
<tr>
<td>N</td>
<td>225</td>
<td>315</td>
<td>420</td>
</tr>
</tbody>
</table>

P values and confidence intervals

<table>
<thead>
<tr>
<th>P values and confidence intervals</th>
<th>P values</th>
<th>Confidence interval</th>
<th>P values</th>
<th>Confidence interval</th>
<th>P values</th>
<th>Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bootstrap by country, restricted</td>
<td>0.267</td>
<td>[-0.009; 0.018]</td>
<td>0.319</td>
<td>[-0.010; 0.021]</td>
<td>0.197</td>
<td>[-0.011; 0.031]</td>
</tr>
<tr>
<td>Bootstrap by country, unrestricted</td>
<td>0.079*</td>
<td>[-0.001; 0.010]</td>
<td>0.079*</td>
<td>[-0.001; 0.013]</td>
<td>0.012**</td>
<td>[0.004; 0.022]</td>
</tr>
</tbody>
</table>

Note: This table presents the effects of drug consumption decriminalization in Portugal in the short-, mid-, and long-term on life expectancy. Additionally, we present two methodologies to compute the standard errors as the number of clusters is limited in this setting. *** p<0.01, ** p<0.05, * p<0.1

In Panel 3 we present the lags and leads model formally defined in Equation (13) to estimate the dynamic effect of decriminalization on life expectancy. In these results we do not find evidence of a positive effect in the first 3 years after the regulatory reform independently of the bootstrapping method. In these 3 periods, time-lapse in which we found negative effects on drug-related deaths, we do not find positive effects on life expectancy. Hence, this evidence suggests that our main results on drug-related deaths are specific and not driven by an overall improvement on health conditions in Portugal.
Panel 3. Dynamic difference-in-difference effects on life expectancy by bootstrapping method

Note: These graphs present the dynamic effect of drug consumption decriminalization on life expectancy. The point estimates are the same in every graph, what varies is the standard errors as we employed two bootstrapping methods as the number of clusters is limited in this setting. The confidence intervals of each estimate correspond to 95%.

Moreover, we tested if there were increases in the supply of health services in Portugal explained by decriminalization in the short-term. In this case, we tested our models with the rate of hospital beds by 1.000 inhabitants. The purpose of this placebo test is to determine, once again, that the reduction in drug-related deaths in the short-term is specifically driven by the decriminalization and it is not confounding with other health related improvements. Certainly, the decriminalization process involves a public health approach for consumption, but the reform should not imply a short-term increase in the number of available hospital beds in the country.

Table 6 presents the results for the difference-in-differences specification in which we found positive and unsignificant effects on hospital beds rate. As this outcome variable is not log transformed, we reported the pre-treatment mean in control countries. The magnitude of the estimate represents the 20%, 23%, and 26% for the short-, medium-, and long-term, respectively, of the pre-treatment mean in non-treated countries. Therefore, we explored through a leads and lags model if in the first periods after the treatment the rate of hospital beds increased to prove that our main results on drug-related deaths are not confounding with the rate of hospital beds.

Table 6. Effects of decriminalization on hospital beds

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Portugal short-term</th>
<th>Portugal medium-term</th>
<th>Portugal long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate</td>
<td>1.249</td>
<td>1.416</td>
<td>1.595</td>
</tr>
<tr>
<td>Cluster-robust SE</td>
<td>0.727</td>
<td>0.773</td>
<td>0.856</td>
</tr>
<tr>
<td>t-statistic</td>
<td>1.72*</td>
<td>1.83*</td>
<td>1.86*</td>
</tr>
<tr>
<td>N</td>
<td>223</td>
<td>313</td>
<td>416</td>
</tr>
<tr>
<td>Pre-treatment mean</td>
<td>6.21</td>
<td>P values and confidence intervals</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>6.21</td>
<td>6.21</td>
<td>6.21</td>
<td>P values</td>
</tr>
<tr>
<td>Bootstrap by country, restricted</td>
<td>0.366</td>
<td>[-5.249; 5.833]</td>
<td>0.341</td>
</tr>
<tr>
<td>Bootstrap by country, unrestricted</td>
<td>0.139</td>
<td>[-0.471; 2.97]</td>
<td>0.135</td>
</tr>
</tbody>
</table>

Note: This table presents the effects of drug consumption decriminalization in Portugal in the short-, mid-, and long-term on hospital beds rate. Additionally, we present two methodologies to compute the standard errors as the number of clusters is limited in this setting. *** p<0.01, ** p<0.05, * p<0.1

These dynamic models are presented in Panel 6. Independently of the bootstrapping method we do not find any significant effects after decriminalization occurred, specially in the first periods after the treatment. Moreover, the parallel trends assumption is not robustly fulfilled as its accomplishment depends on the bootstrapping method employed. Hence, the magnitude of the effects estimated in the static models could be driven, in part, by the negative and statistically significant coefficients prior the treatment. Therefore, these placebo tests point to, once again, the robustness of the main results suggesting a short-term effect on drug-related deaths.

Panel 4. Dynamic difference-in-difference effects on hospital beds by bootstrapping method

Note: These graphs present the dynamic effect of drug consumption decriminalization on hospital beds rate. The point estimates are the same in every graph, what varies is the standard errors as we employed two bootstrapping methods as the number of clusters is limited in this setting. The confidence intervals of each estimate correspond to 95%.

Lastly, we explored as another placebo outcome the mortality rate by cardiovascular disease (CVD), diabetes, cancer, and chronic respiratory disease (CRD). Nevertheless, the availability of this information begins in 2000. Therefore, we are not able to estimate the difference-in-differences model, but it is possible to explore descriptively the evolution of this outcome to determine if Portugal followed an outlier trend in these first periods. Figure 4 presents the trends of this mortality rate in Portugal and in the rest of European countries. These figures suggest than since 2000 there is a general reduction in the mortality rate by these diseases, however, Portugal does not show a disproportionate change during the first years after decriminalization.
relative to other European countries. Additionally, adjusting for 2000 levels, Portugal is one of the countries with lower reduction in the mortality rate prior 2003 as depicted in the adjusted chart (b) of Figure 4. Therefore, this descriptive evidence points to the argument of this subsection suggesting that during the first periods after decriminalization a general health improvement did not occur in Portugal. These placebo tests support our main findings in the short-term as we only find evidence for a specific type of deaths, drug-related.

Figure 4. Mortality by CVD, diabetes, cancer and CRD trends in European countries

a. Unadjusted  
b. Adjusted, 2000 = 0

7. Conclusion

In this paper, we address both an empirical question and a relevant policy debate. Our findings suggest a null long-term effect of the Portuguese decriminalization on drug-related deaths and a positive effect on homicides rate. Theoretically, we demonstrate that, for a certain range of parameters, decriminalization does not alter the long-term risk of dying due to drug consumption. Empirically, we find consistent results as we estimated long-term null effects. However, we find evidence of a reduction on drug-related deaths caused by decriminalization on the first periods after the legal reform. Hence, for the Portuguese case, we demonstrate the existence of a U-shaped effect of decriminalization on drug-related deaths converging to pretreatment levels in the long-term.

In terms of homicides, results are less desirable. Since the third period after decriminalization, our findings suggest positive effects on homicides rate. Through the static difference-in-differences, we estimate an average 28.7%-34.2% increase in homicides rate.
These results are compelling in terms of policy implications. They complement previous findings in which empirical evidence suggested null effects on heroin and cocaine prices of decriminalization (Felix & Portugal, 2017). Moreover, to the best of our knowledge, it is the only intervention that has not led to an increase in rates of drug-related deaths such as supply-side programs in the United States (Balestra et al., 2021; Kim, 2021; Powell et al., 2020). Additionally, theoretical discussions on the consequences of decriminalization are partially solved, for the Portuguese case, with these findings as we demonstrate null effects on drug-related deaths and drugs prices, contradicting theoretical predictions (Bretteville-Jensen, 2006; Husak, 2003; Sher, 2014). However, these results points to a compelling policy implication as decriminalization does not eliminate organized crime nor violence. Nevertheless, these results apply for the Portuguese case but are not, necessarily, valid for other contexts in which this policy could be implemented nor for other drug policy reforms such as the regulation of production. Additionally, this paper points to the need for a comprehensive approach and cost-benefit analysis towards drug policy reform as it suggests effects in different directions depending on the dimension explored. Even if with the current paper and previous evidence we contribute to explore effects of decriminalization on drug-related deaths, homicides and substance prices, there are many dimensions that remain unexplored and must be address in subsequent research. Decriminalization could, for example, change the characteristics of the health service infrastructure enabling a null effect on drug-related deaths and it will be important to understand the changes in this regard. Additionally, drug policy reform could have a potential impact on the prevalence and recreational consumption of substances such as marijuana laws in the United States (DiNardo & Lumieux, 2001; McMichael et al., 2020; Wen et al., 2015; Williams & Bretteville-Jensen, 2006). Lastly, in this paper we focused on the last consequence of problematic use, but the entrance to emergency units could be another variable of interest to explore in further research. All these matters must be face from an evidence-based perspective in order to strengthen knowledge and the worldwide debate around drug policy reform.
8. References


Appendix A.1. Proofs for other cases of the theoretical consumption model

Case 2: $\mu_{LR} > \mu_0$

From equations 3 and 4, if long run consumption is higher than $\tilde{d}$ and $\mu_{LR} < \mu_0$ then

$$\mu_0 < \xi \log (d_{LR})$$  \hspace{1cm} (8')

From (7) and (8)

$$\mu_0 < \xi \log \left( \frac{\varnothing}{\mu_{LR} + \frac{1}{c}} \right)$$  \hspace{1cm} (9')

Proposition 4: If $\varnothing > \left( \frac{p}{c} + \mu_0 \right) e^{\frac{1}{\tilde{\tau}}}$ then $\mu_{LR} > \mu_0$

Proof:

(i) If $\left( \frac{p}{c} + \mu_0 \right) e^{\frac{1}{\tilde{\tau}}} < \varnothing$ then $\frac{1}{\tilde{\xi}} < \log \left( \frac{\varnothing}{1+p_{c}} \right)$ and $1 < \xi \log \left( \frac{\varnothing}{\mu_{LR}+p_{c}} \right)$ for any $\mu_{LR}$

(ii) $\mu_0 < 1$

From i and ii, it follows that $\xi \log \left( \frac{\varnothing}{\mu_{LR}+p_{c}} \right) > \mu_0$

Case 3: $\mu_{LR} < \mu_0$

From equations 3 and 4, if long run consumption is higher than $\tilde{d}$ and $\mu_{LR} > \mu_0$ then

$$\mu_0 > \xi \log (d_{LR})$$  \hspace{1cm} (8'')

From (7) and (8)

$$\mu_0 > \xi \log \left( \frac{\varnothing}{\mu_{LR} + \frac{1}{c}} \right)$$  \hspace{1cm} (9'')

Proposition 5: If $\varnothing \leq \frac{1}{c} + \mu_0$ then $\mu_0 > \mu_{LR}$

Proof:
(i) If $\emptyset \leq p_{\zeta}^{\frac{1}{c}} + \mu_0$ then $\log \left( \frac{0}{\mu_0 + p_{\zeta}^{\frac{1}{c}}} \right) \leq 0$

(ii) $\mu_0 > 0$

From i and ii it follows that If $\emptyset \leq p_{\zeta}^{\frac{1}{c}} + \mu_0$ then $\mu_0 > \mu_{LR}$
Appendix A.2. Yearly correlation of EMCDDA data