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Ex-Ante Analysis of the Costs and Benefits of Legalizing Cannabis Markets in the Czech Republic

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Abstract

Cannabis is the most commonly used illicit drug worldwide. In countries with repressive drug policies, the costs of its prohibition plausibly outweigh the benefits. We conduct a cost–benefit analysis of cannabis legalization and regulation in the Czech Republic, taking into consideration alternative scenarios designed using parameters from the known effects of cannabis legalization in selected U.S. states, Canada, and Uruguay. Our analysis focuses on tax revenues, law enforcement costs, the cost of treatment and harm reduction, and the value of Quality Adjusted Life Years (QALYs). Under all the projected scenarios, the identified benefits of legalizing cannabis for personal use exceed the potential costs. The estimated net social benefit of legalization is in the range of 34.4 to 107.6 million EUR per year (or between 3.2 and 10.1 EUR per capita), depending on the size of the cannabis market and the development of cannabis prices after legalization.

1. Introduction

Cannabis is the most widely used illicit drug both worldwide (UNODC, 2022) and in Europe (EMCDDA, 2020). Repressive drug policies have been shown to have problematic health consequences that negate their officially stated purpose, that is, the protection of public health (Small *et al.*, 2006; Werb *et al.*, 2008; Csete *et al.*, 2016; Scheim *et al.*, 2020). Moreover, when the drug is illicit, cannabis production and distribution evade taxation, the proceeds of which could be used to reduce health harms. Several existing studies argue that repressive cannabis policies should be revised and that alternative approaches might reduce the negative impacts of cannabis on society and the overall social costs associated with illicit cannabis production and consumption (Shanahan & Ritter, 2014; Fischer *et al.*, 2020*a*, *b*).

The social costs associated with cannabis use and repressive cannabis policies can be categorized as follows (Shanahan & Ritter, 2014; Hall, 2020): (i) law enforcement (police, prosecution, and courts – public budgets and lost productivity); (ii) problem use (treatment,

lost productivity, reduced quality of life); (iii) health-related conditions (chronic and acute conditions – treatment and lost productivity); (iv) traffic accidents (law enforcement, property damage, health impacts, lost productivity).

Since 2012, several states of the USA have moved to legalize and regulate cannabis for personal use and to license private entities that supply the regulated market with cannabis (Seddon & Floodgate, 2020). The first country to legalize and regulate cannabis at the national level was Uruguay in 2013; there has since been significant government involvement in the production and distribution of cannabis in Uruguay, where cannabis is available in pharmacies and in community-based cannabis social clubs (Queirolo, 2020). In October 2018, cannabis was also legalized and regulated for personal use in Canada. While the federal government issues licenses to a limited number of producers, provinces have been charged with developing cannabis distribution systems (public, private, or a combination of the two). The main reasons given for the legalization and regulation of cannabis in Canada were to reduce child and youth access to the drug, reduce illicit proceeds, and protect public health and order (Seddon & Floodgate, 2020).

1.1. Cannabis use and cannabis policy in the Czech Republic

In the Czech Republic, cannabis consumption is higher than in most other European countries. According to population surveys, 16.6% of young Czech adults (aged 15–34 years) have used cannabis substances in the last year (Mravčík *et al.*, 2019). Within Europe, this places the Czech Republic behind France (21.8%) Italy (20.9%), and Spain (18.3%), but far ahead of estimates in neighboring countries such as Slovakia (9.3%) or Poland (7.8%) (EMCDDA, 2020).

The relatively high level of cannabis use in the Czech Republic has persisted despite the country's repressive drug policy. Growing or possessing small amounts of cannabis for personal use is an administrative offense in the Czech Republic and it remains a criminal offense to possess cannabis in larger quantities or to produce or distribute cannabis (Belackova & Stefunkova, 2018). Cannabis has been available on prescription for specialist medical purposes in the Czech Republic since 2013, but not for recreational use.

The Police of the Czech Republic investigate approximately 2,000 cannabis-related crimes each year (Policejní prezidium, 2020). This police capacity may be lacking in the prevention, detection, and investigation of other crimes. Also, in 2019, 11.2% of prisoners were serving sentences for offenses related to the production, distribution, and possession of addictive substances, 45% of which were related to cannabis (Generální ředitelství vězeňské služby ČR, 2020). There exists an open political and societal debate on the possible legalization and regulation of cannabis in the Czech Republic.

1.2. Proposed regulation in the Czech Republic

In this paper, we present a cost–benefit analysis of the effects of legalizing and regulating cannabis for personal use by adults in the Czech Republic. The analysis was performed under the auspices of a cross-disciplinary expert group which was tasked with performing a Regulatory Impact Assessment on this subject (Deighton-Smith & Jacobs, 1997). This Regulatory Impact Assessment became the starting point for the draft law on the regulation of cannabis for personal use in the Czech Republic (Belackova *et al.*, 2022). It identified

27 aspects of the cannabis market to be addressed through the design of the regulatory framework and proposed a recommended, evidence-based design for each.

Under the proposed regulatory model, which at the time of preparing this paper has been subjected to political debate and may yet be accepted, revised, or rejected, there would be three legal ways to obtain cannabis for personal use: home growing, cannabis social clubs, and the legal commercial market. Consumers, home growers, cannabis social clubs, commercial growers, distributors/processors, and retailers would be registered with a newly formed Cannabis Bureau, which would be in charge of issuing and controlling licenses for authorized entities (cannabis social clubs, growers, distributors/processors and retailers), as well as granting possession licenses to individuals and home growers. Municipalities may play an important role, as the proposal suggests they would be given the option of imposing local-level regulations before specific establishments are licensed. In terms of the market structure, the proposed model combines elements of good practice from foreign models of cannabis market regulation, including the licensed cannabis market model as implemented in some US states, restrictions on promotion as used in Canada, and registration of all legal consumers, similar to Uruguay. At the same time, the group behind the model recommends making maximum use of harm reduction instruments associated with cannabis use and linking the registration system used for cannabis dispensing with prevention, treatment, and harm reduction services. This kind of link has not been implemented abroad; the proposed model is unique in this respect.

Cost–benefit analyses of cannabis legalization and regulation can be found in the literature. For instance, Van Dijk (1998) conducted a cost–benefit analysis for the Netherlands, comparing the status quo (decriminalization with "coffee shops") with two alternative scenarios: legalization and re-criminalization. He found that neither of the latter scenarios represented a more favorable cost–benefit balance than the current policy. Pudney (2013) carried out a cost–benefit analysis for a licensed, taxed, and regulated cannabis market in the UK and found that this would bring a net benefit. In contrast, for Australia, the net social benefit has been shown to be very similar to the status quo (cannabis use is illegal) as with a legalized and regulated regime (Shanahan & Ritter, 2014). The different results of these various studies may be due to the different starting points in each country in terms of the drug regime as well as differences in the ability to accurately quantify all costs and benefits. Our analysis focuses on the Czech Republic, where cannabis has been decriminalized, cannabis use is prevalent and there is a high proportion of self-growers.

2. Methods

We conduct a cost–benefit analysis to examine the impact of potentially legalizing cannabis for personal use in the Czech Republic. There are some limitations to this analysis when it comes to drug policy. We do not have sufficient available data to cover all possible costs of cannabis legalization and regulation (e.g., the direct healthcare costs associated with treating respiratory and mental health issues due to cannabis use). Equally, some potential benefits cannot be estimated (e.g., intangible or health benefits resulting from consumer protection).

We begin our analysis by focusing on the costs of law enforcement in order to estimate the law enforcement savings that would be made if cannabis were legalized. We then proceed to the direct economic benefits of legalization, that is, the change in the consumer surplus, producer surplus, and tax revenues in the cannabis market. We apply the theoretical implications from the model in Becker *et al.* (2006), which implies that the tax revenues

from the legalized cannabis market exactly capture the net economic benefits from legalization, under certain conditions.

In conventional cost–benefit analyses, tax revenues represent merely a transfer from taxpayers to the government. The welfare analysis in Becker *et al.* (2006) is based on the fact that i) the retail price in the illegal competitive market is equal to the unit production costs and ii) these costs are higher than in a counterfactual legal market because producers and sellers use more costly, clandestine production, transportation, and distribution technologies to avoid being caught. Legalization eliminates these inefficient costs. In the absence of taxation, it would also reduce the retail price.

The excise tax can then be set such that the legal retail price remains the same as in the illegal market. The consumer surplus then would not change. The tax rate fills the wedge between the unchanged price and the new, reduced production costs. The producers' and distributors' cost savings are thus fully captured through tax revenues. In our proposed regulatory framework, the tax is set in exactly this way, to keep the retail price unchanged. The tax revenues thus represent an appropriate measure of the net economic benefits of legalization.[1]

On the social costs side, we consider a potential increase in treatment and harm reduction costs due to a potential increase in cannabis use after legalization and a corresponding increase in demand for such services. Finally, we consider a potential reduction in quality of life from the increased number of people with cannabis use disorder.

In the analysis, we use parameters from jurisdictions where cannabis has already been legalized (Uruguay, Canada, and states of the USA), namely the change in the level of daily cannabis use after legalization and the level of participation in the legal cannabis market. However, besides specific aspects of cannabis regulation in these states (e.g., the level of government regulation, restrictions on advertising, mandatory consumer registration), specific cultural and historical factors have likely shaped the developments in Canada, Uruguay, and the USA. Any jurisdiction seeking to legalize and regulate cannabis may face specific challenges and factors that cannot be captured by other countries' experience.

We further detail the methodology of our estimate below.

2.1. Estimating law enforcement costs

Illegal possession of cannabis entails costs associated with law enforcement. The legalization of cannabis for personal use may reduce these costs significantly, while a proportion of them may remain. We first estimate the costs of the status quo and then estimate the costs for alternative crime reduction scenarios to estimate the potential law enforcement savings from legalization and regulation.

The costs of enforcing cannabis prohibition include both costs borne by the criminal justice sector (the police, public prosecution, courts, and prisons) and the cost of administrative proceedings related to decriminalization.[2]

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[1] This theoretical framework thus allows deriving the economic benefits without assumptions about the demand or supply elasticities. Note that the tax revenues are equal to the increase in the net social benefits of legalization only if the legal retail price is equal to the illegal price. Our proposed reforms satisfies this qualification by design; however, if the excise tax were set differently and the legal price would be higher or lower than the illegal price, the tax revenues could differ from the net social benefits since, e.g., the consumer surplus would change as well.

[2] As standard in cost–benefit analysis, the savings in the costs of enforcing cannabis-related crimes are assumed to fully materialize within the enforcement agencies and not to be offset by other adjustments, for example by the agencies partially reallocating their budget towards enforcement of other crimes.

We include the costs of "primary crime" related to cannabis (that is crimes directly related to the possession, production, and distribution of cannabis). These are defined in Sections 283–287 of the Criminal Code.[3] Administrative cannabis offenses are stated under Act No. 167/1998 Coll., on Addictive Substances, where the primary cannabis offenses are those provided for in Section 39.[4]

"Secondary crime" (e.g., property crimes or crimes committed under the influence of cannabis) could, in principle, also be included in a cost–benefit analysis such as this, but there is no data to support the existence of such crimes in the Czech Republic. We also exclude traffic accidents under the influence of cannabis and their associated social costs: data from Canada and the USA indicate that cannabis legalization alone does not seem to have a significant effect on the number of traffic accidents (Leyton, 2019) or on driving under the influence of cannabis (Rotermann, 2020).

Finally, we divide the total costs of law enforcement associated with illegal cannabis into "direct costs" – the costs of criminal activity and the costs of offenses – and "indirect costs" associated with productivity forgone due to imprisonment. We use a top-down method, multiplying the total variable cost of the activities incurred by the relevant law enforcement and administrative agencies (wages and salaries from the State Final Account of the Czech Republic[5]) by the share of all offenses that are cannabis offenses.

We obtain the share of all offences that are cannabis offences from the following data sources: 1) crime statistics from the Police of the Czech Republic (2020, 2) statistics from prosecutors' offices and courts, which are compiled by the Ministry of Justice (2020), statistics from the Ministry of Health (2020), statistics from the Ministry of the Interior (2020). Additionally, we use cannabis-specific data from an official report on drug use and production (Mravčík *et al.*, 2020). Our estimate of the law enforcement costs related to illicit cannabis in the Czech Republic is based on data for the year 2019 (the most recent year for which complete statistical data are available).

Finally, we assume that legalization would lead to a decrease in cannabis offenses proportionate to the decrease in illicit market activity observed post-legalization in jurisdictions that have legalized cannabis (Uruguay, Canada, states of the USA, see Section 2.2.2). We prefer this approach over a comparison of current trends in cannabis-related offenses in the respective jurisdictions.

2.2. *Estimating tax revenues*

Tax revenue would come from both value-added tax (VAT) and excise tax charged on legal cannabis. The tax revenue is a simple product of the tax rate and the volume of sales or

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[3] These include: Section 283 – Illegal production and other misuse of narcotic and psychotropic substances and poisons; Section 284 – Possession of narcotic and psychotropic substances and poisons; Section 285 – Illegal cultivation of plants containing narcotic or psychotropic substances; Section 286 – Production and possession of an object for the illegal production of narcotic and psychotropic substances and poisons; and Section 287 – Spread of toxicomania. There are no specific cannabis-related crimes; all offences are defined generically for illegal narcotic and psychotropic substances.

[4] These are: Section 39(a) – Unlawfully possesses an addictive substance in small quantities for own use; Section 39(b) – Unlawfully cultivates for own use in small quantities a plant or mushroom containing an addictive substance; and Section 39(c) – Permits the unlawful consumption of an addictive substance by a person under 18 years of age, unless it is a more serious offence.

[5] It can be assumed that after the legalization of cannabis for personal use, these forces would reduce their staffing levels rather than reduce the number of stations, equipment, etc.

quantity on which the tax is assessed. The general VAT rate is already determined by law at 21%, as for most other goods. We derive alternative target levels of the excise tax rate in the next subsection and provide estimates of the size of the future legalized, taxed market in subsection 2.2.2.

2.2.1. Determining the excise tax rate

We follow the recommendation by Kilmer (2015) that the price to the consumer (inclusive of taxes) after legalization should be similar to the price of cannabis on the illegal market. Hence, the target level of excise tax should not lead to an increase in the retail price. This is possible – despite the fact that the current illegal market is untaxed – since legalization should reduce production and distribution costs. This implies that the price in the wholesale (WS) market for cannabis and the retail markup charged in the retail segment (the difference between the wholesale and retail price) should decrease. The VAT and excise tax should be set to offset these decreases, such that retail cannabis prices do not change after legalization. Below we present alternative assumptions about plausible reductions in the wholesale price and the retail markup and derive the resulting excise tax rates. A formal, more detailed derivation is presented in the Appendix.

The current (illegal) price of dry cannabis in the Czech Republic is 200 CZK/g (7.8 EUR/g).[6] Counting with 21% VAT, the price after legalization would thus be 6.4 EUR/g excluding VAT.[7]

The retail markup on the present illegal market is estimated at 2 EUR/g or 33%, based on a wholesale price of 5.8 EUR/g.[8] We consider two scenarios for retail markup after legalization: first, a small decrease in the retail markup from 33% to 24% (i.e., a 28% decrease), and second a substantial decrease in the retail markup from 33% to 12% (i.e., a 64% decrease).

The current average wholesale price of 5.8 EUR/g substantially exceeds the average cost of illegal indoor production, which (Vopravil, 2011) estimated to be 2.3 EUR/g. There is thus substantial scope for a reduction in the wholesale price, through reductions in both production costs and the wholesale markup. Both are predicted to reduce after legalization since legalization would eliminate the need for risk premia embedded in prices to compensate producers and sellers for the risks of detection, confiscation of drugs, and sanctions. Legalization would also allow producers and sellers to adopt more efficient technologies, as they would no longer need to hide their activities (Becker *et al.*, 2006). We consider three alternative scenarios for the decrease in wholesale prices: a small decrease by 12.5% to 5.1 EUR/g, a medium decrease by 25% to 4.4 EUR/g, and a substantial decrease by 50% to 2.9 EUR/g.

Table 1 shows six options (O1–O6) for the excise tax rate that are implied by the alternative combinations of scenarios for the decreases in the retail markup and the wholesale price. The excise tax rate could range from 0.1 to 3.2 EUR/g. Some of the combinations considered are more plausible than others; we narrow down the range of preferred excise tax rates when presenting our tax revenue estimates in Section 3.2.

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[6] The average exchange rate in 2019 was 25.672 CZK/EUR.

[7] This implies VAT of 1.4 EUR/g.

[8] The estimate is based on data from the National Monitoring Centre for Drugs and Addiction published in the Drug Situation in the Czech Republic in 2019. However, alternative estimates suggest that the retail price may be lower (Havlíčková, 2018).

Table 1. *Options for determining the excise tax rate*

	% Markup decrease	Final markup level	% Decrease in WS prices	Final WS price per gram	% Change in the gap between WS price and production costs	Implied excise tax per gram
O1: Substantial decrease in markup, the substantial decrease in WS price	−64.0%	12%	−50.0%	2.9 EUR	−83.3%	3.2 EUR
O2: Substantial decrease in markup, medium decrease in WS price	−64.0%	12%	−25.0%	4.4 EUR	−41.7%	1.5 EUR
O3: Substantial decrease in markup, small decrease in WS price	−64.0%	12%	−12.5%	5.1 EUR	−20.8%	0.7 EUR
O4: Small decrease in markup, a substantial decrease in WS price	−28.0%	24%	−50.0%	2.9 EUR	−83.3%	2.8 EUR
O5: Small decrease in markup, medium decrease in WS price	−28.0%	24%	−25.0%	4.4 EUR	−41.7%	1.0 EUR
O6: Small decrease in markup, small decrease in WS price	−28.0%	24%	−12.5%	5.1 EUR	−20.8%	0.1 EUR

2.2.2. *Market size and the share of the legal (taxable) market*

The existing literature provides varying estimates of the current size of the market for cannabis in the Czech Republic. A lower estimate (20.1 tons per year) comes from the Annual Report on the Drug Situation in the Czech Republic in 2019, using data from 2016. However, international research presents higher estimates: 55.9 tons (Costes & Lakhdar, 2009) or between 27.2 and 51.3 tons (Trautmann *et al.*, 2013). All these estimates of the cannabis market rely on general population surveys on cannabis use, but differences exist in their assumptions about the amount of cannabis consumed by an average person on an average day (Caulkins *et al.*, 2020).

For the purpose of this study, we use two cannabis market estimates – a *high estimate* and a *low estimate*. The *high estimate* is derived from the data on monthly cannabis consumption from the 2016 representative population survey on substance use and includes the quantities of cannabis use reported in the same study. This data implies that 46.3 tons of (illegal) cannabis is consumed annually in the Czech Republic. The *low estimate* is taken from the Annual Report on Drug Situation in the Czech Republic in 2019, referred to above, at 20.1 tons annually. After legalization, the prevalence of cannabis use could increase. We base our estimate on the experience in Canada, where legalization led to a 4% increase in cannabis consumption, according to estimates presented by Rotermann (2020). A 4% increase in the Czech Republic implies a market size post-legalization of 20.9 (*low estimate*) or 48.2 tons (*high estimate*) of cannabis.

Only part of that cannabis market would be subject to taxation. Previous work (Vopravil, 2011) has shown that a significant proportion of cannabis production in the Czech Republic is for its own use, that is for consumption by the growers themselves and their friends. After legalization, in our regulatory model, this segment of the market would remain untaxed, although this segment's size as a share of total cannabis consumption could shift in either direction. The proportion of cannabis used for personal consumption could range anywhere between 59% (Mravčík *et al.*, 2012) and 70% (Vopravil, 2011); conversely, only 30%–41% of cannabis might be sold on the commercial market and therefore taxed.

Secondly, in the jurisdictions that have legalized cannabis to date, part of the cannabis market has remained illegal. In Canada, after legalization, approximately 52% of consumers buy their cannabis on the legal market (Rotermann, 2020). In Washington State (USA), the share of the black market has decreased to 30% after legalization, while 7% of people who use cannabis have continued to grow their own, amounting to about 63% of cannabis consumption via legal outlets (Caulkins & Kilborn, 2019). In Uruguay, approximately 25% of all people who use cannabis have registered with the state authority and about 75% of them obtain their cannabis from pharmacies; this makes the proportion of legal sales of cannabis on the commercial cannabis market in Uruguay only 19% (Queirolo, 2020).

We consider five alternative scenarios for the size of the (taxable) cannabis market in the Czech Republic after legalization, based on the market size provided above and the estimated proportion of legal retail sales: 1) 41%, which is the current maximum size of the illegal commercial market in the Czech Republic – this figure thus implies that the future formal market would be similar in size to the current informal market; 2) 19%, which corresponds to the situation after legalization in Uruguay; 3) 52%, which corresponds to the situation after legalization in Canada; 4) 63%, which corresponds to the situation after legalization in Washington State; and 5) 100%, which is a benchmark scenario in which the entire future cannabis market would be taxable. Albeit unrealistic, this represents the

maximum revenue potential of the legalized market in which all consumption is effectively taxed.

2.3. *Estimating the costs of cannabis use disorder and its treatment*

The main type of social cost associated with cannabis pertains to its problematic (heavy or daily) use and the resulting cannabis use disorder, also referred to as dependence (Degenhardt *et al.*, 2017; Hall, 2020). There are adverse consequences of heavy cannabis use on the respiratory and cardiovascular systems, and possibly also mental health (World Health Organization, 2016; Jouanjus *et al.*, 2017; Gracie & Hancox, 2021). However, we do not have access to data that could allow us to estimate the cost of health care associated with heavy use of cannabis for this study. The only direct healthcare cost we estimate is the cost of treating cannabis use disorder (CUD). We do this by examining four different scenarios of change in the number of people with CUD (see below), as well as three options under each scenario depending on the proportion of people who seek treatment for their CUD.

To calculate four different scenarios of a possible increase in CUD, we use the number of people who use cannabis daily in three of the four scenarios (a direct estimate of people with CUD was missing), referring to the Czech Republic in 2016 as a baseline ($n = 13,620$). See the respective scenarios below:

- *Scenario 0* – no change in the number of people who use cannabis daily.
- *Scenario 1* – a 10% increase in the number of people who use cannabis daily (derived from a 50% increase in the lifetime prevalence of cannabis use in Uruguay, from 20% in 2011 to 30.2% in 2018, and the observation that 1 in 5 people who use cannabis will develop CUD in the future, see Junta Nacional de Drogas, 2019 and Leng et al., 2020).
- *Scenario 2* – a 2% increase in people who use cannabis daily, similar to Canada where their number increased from 5.8% to 6% following legalization (Rotermann, 2020).
- *Scenario 3* – a 36% increase in CUD among adults (from 0.9% to 1.23%), based on a comparison of pre- and post-legalization data in states that have and have not legalized cannabis for personal use (Cerdá *et al.*, 2020).

We also assume that the proportion of people with CUD in treatment might change over time with further investments into the treatment of cannabis dependence after legalization and with decreasing stigma related to cannabis use. In 2016, 8% of people who use cannabis daily in the Czech Republic were in treatment (Option 1); we assume an increase to 15% (Option 2), as well as to 30% (Option 3). Based on these possible increases, we estimate the potential increase in the cost of treatment for cannabis dependence (Table 4).

In addition to the cost of treatment, we seek to quantify and monetize the impact of cannabis legalization and regulation by estimating its effect on Quality Adjusted Life Years (QALYs). QALYs are used primarily in pharmaco-economics and consist of the number of life years gained from an intervention, adjusted by the quality of life gained from this intervention. Quality of life is measured on a scale between 0 and 1 across several areas, such as self-care and/or mental health (Gudex *et al.*, 1988; Cohen, 1996).

Some countries specify a monetary value per QALY, in order to determine whether the benefits in QALYs from particular interventions/treatments outweigh the treatment costs. For example, the value per QALY in the Czech Republic has previously been determined as 40,000 EUR (Kříž, 2011). Conversely, 1 year of life lived in full health is valued at 40,000 EUR. This feature of QALYs (in that intangible value of life quality and its duration,

translates into money) can be useful in estimating social costs, although such applications of QALYs remain limited (Belackova, 2008). In this study, we use QALYs to make a monetary estimate of the impact of cannabis legalization in terms of increasing (rather than decreasing) the number of people with CUD.

We assume that life expectancy will remain the same among people with CUD according to the four scenarios outlined above, but their quality of life will decrease. We calculate the change in the quality of life from the general population is 0.85 (Belackova, 2008) to people with CUD decreasing by −0.113 (Begg *et al.*, 2007; Deogan *et al.*, 2015), and calculate the resulting decrease in social costs (see Table 5).

3. Results

3.1. *Estimated impact of cannabis legalization and regulation on law enforcement costs*

The total direct costs incurred by the police, public prosecutor, courts, and prisons for criminal offenses related to cannabis amounted to 16.8 million EUR in 2019. Additionally, the direct cost of investigating administrative offenses related to cannabis was 2.7 million EUR (this involved enforcement by the state police, municipal police, and municipal governments). In addition, there were indirect costs associated with individuals' loss of productivity while imprisoned in relation to cannabis, estimated at 15 million EUR. In sum, the direct and indirect costs of enforcing cannabis laws under the status quo were 34.5 million EUR in 2019.

We use five scenarios to estimate the proportion of the cannabis market that might remain illegal post-legalization as a proxy for the expected decrease in cannabis crimes.

Under Scenario 1, all cannabis use remains illegal even under regulation, and thus there is no reduction in enforcement costs. Under Scenario 2 (Uruguay) the total estimated enforcement costs decline by 17.9 million EUR, or 51.9% compared to the status quo. The estimated decrease in law enforcement costs in Scenario 3 (Canada) would be 20.6 million EUR, or 59.7% compared to the status quo. The estimated decrease in Scenario 4 (Washington) would be 24.1 million EUR, or 69.9% compared to the current situation. Finally, in Scenario 5 (100% participation in legal market) there would be no law enforcement costs, which represents a decrease of 100% or 34.5 million EUR.

3.2. *Estimated impact of cannabis legalization and regulation on tax revenue*

Tables 2 and 3 present the estimated tax revenues separately for the two market size estimates – the *low estimate* of 20.9 tons and the *high estimate* of 48.2 tons. The tables are further broken down to present estimates for each scenario for the shares of the legal (taxable) market and for alternative target excise tax rates, as derived in Section 2.2.

Given the range of alternative assumptions about the market size, share of the taxable market, and excise tax rate, the estimated tax revenues vary significantly. The market size assumptions substantially affect the tax revenue, where the low estimate leads to an estimated tax revenue in the range of 5.8 million to 94.4 million EUR, while the high estimate yields an estimate between 13.3 million and 217.8 million EUR.

Table 2. *Estimated tax revenues (in millions of EUR) – low market size estimate*

Market size estimate		Low: 20.9 tons				
		Scenarios for the Share of the Taxable Market				
Legal market share		Czech Republic at present 41%	Uruguay after legalization 19%	Canada after legalization 52%	Washington state (USA) after legalization 63%	100%
Excise tax options	Rate					
O1: Substantial decrease in markup, the substantial decrease in WS price	3.2 EUR	27.1	12.6	34.4	41.7	66.2
O2: Substantial decrease in markup, medium decrease in WS price	1.5 EUR	13.1	6.1	16.3	20.1	32.0
O3: Substantial decrease in markup, small decrease in WS price	0.7 EUR	6.1	2.8	7.7	9.4	14.9
O4: Small decrease in markup, a substantial decrease in WS price	2.8 EUR	24.1	11.2	30.6	37.1	58.9
O5: Small decrease in markup, medium decrease in WS price	1.0 EUR	8.61	4.0	10.9	13.2	21.0
O6: Small decrease in markup, small decrease in WS price	0.1 EUR	0.8	0.4	1.1	1.3	2.0
VAT	21%	11.6	5.4	14.7	17.8	28.2

Table 2. *Continued*

Market size estimate		Low: 20.9 tons				
		Scenarios for the Share of the Taxable Market				
Legal market share		Czech Republic at present 41%	Uruguay after legalization 19%	Canada after legalization 52%	Washington state (USA) after legalization 63%	100%
Excise tax options	Rate					
Excise tax + VAT revenues						
O1: Substantial decrease in markup, a substantial decrease in WS price	3.2 EUR	38.7	18.0	49.1	60.0	94.4
O2: Substantial decrease in markup, medium decrease in WS price	1.5 EUR	24.7	11.5	31.0	37.9	60.2
O3: Substantial decrease in markup, small decrease in WS price	0.7 EUR	17.7	8.2	22.4	27.2	43.1
O4: Small decrease in markup, a substantial decrease in WS price	2.8 EUR	35.7	16.6	45.3	54.9	87.1
O5: Small decrease in markup, medium decrease in WS price	1.0 EUR	20.2	9.4	25.6	31.0	49.2
O6: Small decrease in markup, small decrease in WS price	0.1 EUR	12.4	5.8	15.7	19.1	30.3

Table 3. *Estimated tax revenues (in millions of EUR) – high market size estimate*

Market size estimate		High: 48.2 tons				
		Scenarios for the share of the taxable market				
Legal market share		Czech Republic at present 41%	Uruguay after legalization 19%	Canada after legalization 52%	Washington state (USA) after legalization 63%	100%
Excise tax options	Rate					
O1: Substantial decrease in markup, a substantial decrease in WS price	3.2 EUR	62.3	29.0	79.4	96.2	152.6
O2: Substantial decrease in markup, medium decrease in WS price	1.5 EUR	30.2	14.0	38.3	46.5	73.7
O3: Substantial decrease in markup, small decrease in WS price	0.7 EUR	14.1	6.5	17.8	21.6	34.3
O4: Small decrease in markup, a substantial decrease in WS price	2.8 EUR	55.7	25.8	70.6	85.5	135.7
O5: Small decrease in markup, medium decrease in WS price	1.0 EUR	19.9	9.2	25.2	30.5	48.4
O6: Small decrease in markup, small decrease in WS price	0.1 EUR	1.9	0.9	2.4	2.9	4.7
VAT	21%	26.7	12.4	33.9	41.0	65.1

Table 3. *Continued*

Market size estimate		High: 48.2 tons				
		Scenarios for the share of the taxable market				
Legal market share		Czech Republic at present 41%	Uruguay after legalization 19%	Canada after legalization 52%	Washington state (USA) after legalization 63%	100%
Excise tax options	Rate					
Excise tax + VAT revenues						
O1: Substantial decrease in markup, a substantial decrease in WS price	3.2 EUR	89.0	41.390	113.2	137.2	217. 8
O2: Substantial decrease in markup, medium decrease in WS price	1.5 EUR	57.0	26.4	72.2	87.5	138.9
O3: Substantial decrease in markup, small decrease in WS price	0.7 EUR	40.8	18.9	51.7	62.6	99.4
O4: Small decrease in markup, a substantial decrease in WS price	2.8 EUR	82.4	38.2	104.4	126.5	200.9
O5: Small decrease in markup, medium decrease in WS price	1.0 EUR	46.6	21.6	59.0	71.5	113.6
O6: Small decrease in markup, small decrease in WS price	0.1 EUR	28.7	13.3	36.3	44.0	69.8

Table 4. *Cost of treating cannabis use disorder*

	Scenarios for change in the number of people with CUD/who use cannabis daily			
	No change in the number of people who use cannabis daily	Uruguay - 10% increase (50% increase in lifetime prevalence of cannabis use, 1 in 5 develop problem use)	Canada - 2% increase in people who use cannabis daily	USA - 36% increase in people who develop a cannabis use disorder
Increase in the number of people with CUD/who use cannabis daily	0	1,362	272	4,903
The proportion of people with CUD/who use cannabis daily who are in treatment				
Option 1: 8% (same as current proportion)	1,141	1,199	1,164	1,482
Option 2: 15%	2,043	2,247	2,084	2,778
Option 3: 30%	4,086	4,495	4,168	5,557
Cost of treatment (millions of EUR)				
Option 1: 8% (same as current proportion)	3. 5	3.7	3.6	4.5
Option 2: 15%	6.2	6.9	6. 4	8. 5
Option 3: 30%	12.5	13.7	12.7	17.0
Multiple current treatment occupancy				
Option 1: 8% (same as current proportion)	1.0	1.1	1.0	1.3
Option 2: 15%	1.8	2.0	1.8	2.4
Option 3: 30%	3.6	3.9	3.7	4.9

Table 4. *Continued*

	Scenarios for change in the number of people with CUD/who use cannabis daily			
	No change in the number of people who use cannabis daily	Uruguay - 10% increase (50% increase in lifetime prevalence of cannabis use, 1 in 5 develop problem use)	Canada - 2% increase in people who use cannabis daily	USA - 36% increase in people who develop a cannabis use disorder
Increase in costs compared to the current situation (millions of EUR)				
Option 1: 8% (same as current proportion)	0.0	0.2	0.1	1.0
Option 2: 15%	2.8	3.4	2.9	5.0
Option 3: 30%	9.0	10.2	9.2	13.5

Table 5. *Estimation of lost QALYs and conversion to their monetary value (millions of EUR)*

		Scenarios for change in the number of people with CUD/who use cannabis daily			
	Current level	No change in the number of people who use cannabis daily	Uruguay - 10% increase (50% increase in lifetime prevalence of cannabis use, 1 in 5 develop problem use)	Canada - 2% increase in people who use cannabis daily	USA - 36% increase in people who develop a cannabis use disorder
Increase in the number of people with CUD/who use cannabis daily	13,620	0	1,362	272	4,903
Option 1 - the same proportion of people with CUD/who use cannabis daily as current (8%)					
Number of people with CUD/who use cannabis daily	13,620	13,620	14,982	13,892	18,523
Number of people in treatment (8% - current proportion)*	1,141	1,141	1,255	1,164	1,552
Change in QALYs due to legalization		0.0	−137.3	−27.5	−494.2
Conversion to EUR (1 QALY equivalent to 40,000 EUR)		0	−5.5	−1.1	−19. 8
Option 2 – double the proportion of people with CUD/who use cannabis daily from current (15%)					
Number of people with CUD/who use cannabis daily	13,620	13,620	14,982	13,892	18,523

Table 5. *Continued*

		Scenarios for change in the number of people with CUD/who use cannabis daily			
	Current level	No change in the number of people who use cannabis daily	Uruguay - 10% increase (50% increase in lifetime prevalence of cannabis use, 1 in 5 develop problem use)	Canada - 2% increase in people who use cannabis daily	USA - 36% increase in people who develop a cannabis use disorder
Number of people in treatment (15% - increase)*	1,141	2,043	2,247	2,084	2,778
Change in QALYs due to legalization		99.2	−127.3	−25.5	−458.4
Conversion to EUR (1 QALY equivalent to 40,000 EUR)		0	−5.1	−1.0	−18.3
Option 2 – four times the proportion of people with CUD/who use cannabis daily from current (30%)					
Number of people with CUD/who use cannabis daily	13,620	13,620	14,982	13,892	18,523
Number of people in treatment (30% - increase)*	1,141	4,086	4,495	4,168	5,557
Change in QALYs due to legalization		324.0	−104.9	−21.0	−377.5
Conversion to EUR (1 QALY equivalent to 40,000 EUR)		0	−4.2	−0.8	−15.1

*For people who are in treatment for cannabis use disorder, we assume the same quality of life as in the general population (0.85); for the remaining people with CUD/who use cannabis daily, we assume decreased quality of life (0.74).

3.3. Costs associated with cannabis use disorder

The loss of QALYs resulting from the increased number of people with cannabis use disorder after legalization ranges from 0.8 million EUR (Scenario 2: a 2% increase in people who use cannabis daily; Option O3: 30% of people with CUD/who use cannabis daily) to 29.8 million EUR (Scenario 3: a 2% increase in people who use cannabis daily; Option O1: 8% of people with CUD/who use cannabis daily in treatment), as shown in Table 4.

3.4. Increasing treatment capacity and harm reduction and cost implications

Table 5 presents the number of people who would be in contact with cannabis treatment and harm reduction programs under three different options (status quo, doubling, and quadrupling the capacity of treatment and harm reduction services). Option O3 (30% of people with CUD/who use cannabis daily in treatment) would imply an increase in the capacity of treatment and harm reduction services by up to five times the current situation, from treating 1,141 persons currently to between 4,249 and 5,557 persons after post-legalization expansion.

Such an increase in treatment capacity would incur a cost to public budgets of between 3.7 million EUR and 17 million EUR. This represents an increase in the costs of treatment and harm reduction of between 0.2 million EUR and 13.5 million EUR compared to the current situation.

4. Discussion and conclusion

In this study, we aimed to quantify the main social costs and benefits of the potential legalization and regulation of cannabis for personal use in the Czech Republic and perform a cost–benefit analysis that considers law enforcement costs, tax revenue, cannabis-related harm, and cannabis treatment.

Our analysis relied on several key outcomes from jurisdictions that have legalized cannabis in the past, namely Uruguay, Canada, and individual states in the USA. The main parameters used in this study were the legal versus illegal market shares, the increase in cannabis use after legalization, and the proportion of daily cannabis use. We have outlined multiple scenarios and options for potential costs and benefits, based on the parameters described above. To reach a final conclusion about the potential costs and benefits of cannabis legalization and regulation in the Czech Republic, we have carefully considered which of those scenarios/options are the most realistic.

Of the five scenarios we used to model post-legalization participation in the legal market which were: 1) the status quo – identical formal and informal market shares as in the Czech Republic today; 2) a situation like that observed after legalization in Uruguay, 3) a situation like that observed after legalization in Canada, 4) a situation like that observed after legalization in the USA and 5) 100% participation in the legal formal market), realistically we would expect post-legalization developments in the Czech Republic to be similar to those in the United States or Canada given that the proposed model for cannabis regulation and the market structure in the Czech Republic share similarities with those in these countries; very low legal market participation was observed in Uruguay primarily due to problems with insufficient production and a small number of legal cannabis shops (Queirolo, 2020).

We estimate that the cost savings pertaining to decreased law enforcement following cannabis legalization and regulation would be between 20.7 and 24.2 million EUR. In terms

of the optimal tax rate, based on current costs and markups in the illegal markets and experience in Canada and the United States, we believe that options O2 (tax rate 1.5 EUR/g), O3 (tax rate 0.7 EUR/g), and O5 (tax rate 1 EUR/g) reflect realistic decreases in the retail markup and wholesale cannabis price.

4.1. Cost and benefits of cannabis legalization and regulation

To estimate the cost and benefits of cannabis legalization and regulation, we have narrowed down our estimates to fewer options. In particular, we have selected one high and one low scenario for post-legalization law enforcement savings, tax revenue, daily cannabis use, and treatment costs. In selecting these, we have focused on the most plausible course of development following cannabis legalization and regulation in the Czech Republic.

We have determined that for savings in law enforcement costs, Scenarios 3 (Canada) and 4 (USA) were most plausible due to the fact that the (projected) legal cannabis market in the Czech Republic might have a similar market share to those observed in these jurisdictions since the proposed regulatory framework in the Czech Republic shares many similarities with those in place in Canada and in Washington State. We estimate that the savings to law enforcement costs due to legalization in the Czech Republic would range between 20.7 and 24.1 million EUR.

In determining the tax revenue, we have assumed that a politically plausible tax rate in the Czech Republic would fall between 0.7 and 1.5 EUR per gram of dry cannabis. We have also factored in the formal (taxable) market share in the Czech Republic, which would probably be similar to that in Canada (52%) or Washington State (63%) due to similarities in the proposed regulatory framework. Narrowing down the tax revenues to these two options, we estimate the tax revenue post-legalization in the Czech Republic would be between 22.4 million EUR and 38 million EUR annually for our low market size estimate (20.9 tons) and between 51.7 million EUR and 87.5 million EUR annually for our high market size estimate (48.2 tons).

In determining the most plausible treatment and harm reduction costs, we have chosen Scenarios 1 (Uruguay) and 2 (Canada) because the cannabis policies in these countries include stronger regulations in this regard than those in the USA. We have also determined that it is likely there would be a slight increase in daily cannabis use post-legalization in the Czech Republic (as outlined in Option O2). Altogether, we estimate that the costs of cannabis-related treatment and harm reduction would increase post-legalization in the Czech Republic by 2.9 to 3.4 million EUR annually. We applied similar assumptions when narrowing down the options for loss of QALYs and the associated costs, yielding an estimated cost from loss of quality of life of between 1.1 and 5.5 million EUR.

Table 6 shows an overview of the estimated costs and benefits related to cannabis use legalization and regulation for the subset of the most plausible scenarios and options.

4.2. Benefits outweigh costs in all plausible scenarios and options

In terms of societal costs and benefits (including the cost of lost QALYs due to the reduced quality of life of people with CUD), our analysis shows that the potential benefits of cannabis legalization and regulation outweigh the costs. Table 6 shows the net social benefits between 11.7 and 91.6. Taking into account the most plausible options and scenarios mentioned above, the estimated total net societal benefit ranges between 34.4 and 107.6 million EUR. This rather wide range results from the fact that we have incorporated multiple

Table 6. *Overview of costs and benefits related to cannabis use under realistic scenarios and options for legalization and regulation (millions of EUR)*

	Scenarios for the share of the taxable market		
	Uruguay	Canada	USA
Impact on public budgets			
Total law enforcement savings	17.9	20.6	24.1
Tax revenue - estimated market size of 20.9 tons			
O2: Substantial decrease in markup, medium decrease in WS price, tax rate 1.5 EUR/g	11.5	31.0	37.9
O3: Substantial decrease in markup, small decrease in WS price, tax rate 0.7 EUR/g	8.2	22.4	27.2
O5: Small decrease in markup, medium decrease in WS price, tax rate 1 EUR/g	9.4	25.6	31.0
Tax revenue - estimated market size of 48.2 tons			
O2: Substantial decrease in markup, medium decrease in WS price, tax rate 1.5 EUR/g	26.4	72.2	87.5
O3: Substantial decrease in markup, small decrease in WS price, tax rate 0.7 EUR/g	18.9	51.7	62.6
O5: Small decrease in markup, medium decrease in WS price, tax rate 1.0 EUR/g	21.6	59.0	71.5
Increase in treatment costs and harm reduction compared to the current situation			
8% of people with CUD/who use cannabis daily are in treatment	0.2	0.1	1.0
15% of people with CUD/who use cannabis daily are in treatment	3.4	2.9	5.0
30% of people with CUD/who use cannabis daily are in treatment	10.2	9.2	13.5
SOCIAL COSTS (other than within public budgets)			
Increase in the number of people with CUD/who use cannabis daily - conversion to EUR (1 QALY equivalent of 40,000 EUR)			
The same proportion of people with CUD/who use cannabis daily in treatment as current (8%)	−5.5	−1.1	−29.8
15% of people with CUD/who use cannabis daily in treatment	−5.1	−1.0	−18.3
30% of people with CUD/who use cannabis daily in treatment	−4.2	−0.8	−15.1
Net social benefit			
- Minimal estimation	+11.7	+33	+20.5
- Maximal estimation	+38.6	+91.6	+88.3

parameters into our analysis using various scenarios and options, in particular, to address uncertainties regarding the true size of the cannabis market in the Czech Republic. In terms of public budgets, the proposed legalization and regulation of cannabis in the Czech Republic would have a net benefit of between 33.2 and 102.3 million EUR.

To see what the minimum benefits of cannabis legalization and regulation might be, we can take the parameters of cannabis legalization in Uruguay and assign the respective costs and benefits from the Czech Republic. With low consumer participation in the legal market, as in Uruguay, tax revenue would be rather low (8.2 million EUR) and so would savings on law enforcement costs (17.9 million EUR). Nevertheless, these benefits could still outweigh the social costs – 4.2 million EUR associated with the loss of QALYs and treatment costs of 10.2 million EUR, in total 11.7 million EUR.

At the opposite end of the range, we show that the highest excess of revenues over costs would be achieved with a larger market (48.2 tons), an excise duty rate of 1.5 EUR/g of cannabis, and legal market parameters similar to Canada. Under this scenario, the benefits (tax revenue + law enforcement savings) would reach 92.8 million EUR, while the costs associated with cannabis use disorder and treatment would be just 1.2 million EUR. The benefits would therefore exceed the costs about 80 times.

Overall, our analysis shows that the tax revenue and law enforcement savings following cannabis legalization and regulation in the Czech Republic would very likely outweigh any additional costs of treatment and harm reduction programs related to cannabis legalization as well as a potential decrease in QALYs due to increased cannabis use. These savings could be allocated to fund public services that further mitigate any adverse effects of cannabis legalization (e.g., prevention campaigns or drug-driving interventions), as well as to cover the increased costs of overseeing the legal cannabis market (e.g., an agency for cannabis market regulation or an information system with individual consumer accounts to prevent diversion from the legal market).

4.3. Limitations

Although our results provide new insights, certain limitations of this research need to be considered. The cost–benefit analysis of legalization faces several challenges. Intangible and hard-to-quantify impacts, such as social justice and health effects, are difficult to express monetarily. Additionally, estimating the size of the market and calculating tax revenues can vary widely; this is, admittedly, reflected in the dispersion of the tax revenue estimates. The availability and quality of data may be limited, leading to potential inaccuracies. This analysis is restricted to categories of costs and benefits that were feasible to calculate for this report. Other benefits, such as increased consumer protection, reduced stigma, or reduced transaction costs were not fully accounted for. Conversely, problematic cannabis use can contribute to chronic diseases and acute health conditions, negatively impacting individual labor productivity, increasing absenteeism, and affecting employment stability (Henkel, 2011). However, current research on cannabis use and labor market outcomes shows mixed results, with some studies indicating negative effects while others suggest the impact may be less severe than previously thought. For example, Bears Augustyn *et al.* (2020) found that cannabis use is linked to a reduced likelihood of full-time employment, though employment stability remains high for individuals who are employed. Similarly, it is difficult to quantify the social justice impacts when using cost–benefit analysis to decide on possible cannabis regulation. Many important benefits and costs, such as the reduction of racial disparities in arrests and the improvement of community relations, cannot be easily expressed in monetary terms. These value judgments play a crucial role in the overall assessment of cannabis legalization, as highlighted by Wilkins *et al.* (2022). Thus, while this

analysis may not be fully incomplete, it provides an understanding of the primary costs and benefits of cannabis legalization.

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Appendix. Tax model

The objective of the tax model is to find the target level of the excise tax rate and to derive an estimate of the tax revenues from the legalized regulated cannabis market. In the proposed regulatory framework, the excise tax is set as a tax per gram of THC contained in the cannabis product. However, the analysis is far simpler computationally when we first work with a tax per gram of dry matter (Q_m - "market quantity") and only subsequently convert this into a tax per gram of THC.

The starting point for this analysis is the intention – set as a policy objective for the legalized market – that the retail price for the end consumer in the legalized market should be the same as the current price in the illegal market. The excise tax rate must be targeted to achieve that objective. The model divides the legalized market into two segments. The first segment is the commercial market, that is production and sales to end consumers. In this market, the state will collect excise tax and value-added tax (VAT), which we here model as a single tax (T_m – "commercial market tax rate") per unit of market quantity.

The second segment consists of self-growers and cannabis clubs that is cannabis that is both grown and consumed by end consumers. This production does not pass through the market and is not subject to taxation.

The total tax revenue to public budgets from legalization will therefore be given by the following equation:

$$T = T_M * Q_M. \tag{1}$$

The current observed retail price P_M^0 in the illegal market consists of the wholesale price P_S^0 and the retail markup m^0, that is the difference between the retail and wholesale prices. The wholesale price is primarily determined by the costs of production and wholesale distribution. The markup is determined primarily by the cost of retail distribution and sales to end consumers. In an illegal market, both are significantly influenced by the need to choose inefficient technologies and business practices to avoid detection by law enforcement authorities. Prices and markups also take into account the risks of detection, confiscation of drugs and means of production, and criminal sanctions (Caulkins & Reuter, 1998):

$$P_M^O = P_S^O + m^O. \tag{2}$$

The changes in prices, markups, and taxes that occur after legalization play a key part in setting the tax rate T_m. The change in the retail price of P_m can be decomposed into the following terms:

$$\frac{dP_M}{P_M^O} = \frac{dP_S}{P_M^O} + \frac{dm}{P_M^O} + \frac{T_M}{P_M^O}$$

$$\frac{dP_M}{P_M^0} = \frac{dP_S}{P_S} * \frac{P_S}{P_M^0} + \frac{dm}{m} * \frac{m}{P_M^0} + \frac{T_M}{P_M^0}$$

$$\frac{dP_M}{P_M^0} = \frac{dP_S}{P_S} * (1 - \mu) + \frac{dm}{m} * \mu + \frac{T_M}{P_M^0}. \tag{3}$$

In the legalized market, the costs of production and distribution are expected to fall by eliminating the inefficiencies and risks associated with the illegal market, causing reductions in wholesale prices and retail markups. There will also be an opening up of competition in the market. Economies of scale can be expected and legalization itself may lead to innovation in the market, as producers may look for ways to reduce costs and increase profitability. These factors should push for further reductions in wholesale prices and retail markups.

As the target retail price in the legal market equals the price in the current illegal market, the percentage change in retail price can be derived from $\frac{dP_M}{P_M^0} = 0$. The market tax rate would therefore be equal to the percentage decrease in the wholesale price and the percentage decrease in the markup:[9]

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[9] From a different perspective, the legalized market generates welfare gains by making production and distribution more efficient, and these gains manifest as a reduction in the pre-tax retail price paid by end consumers. The tax rate that is equal to the difference between the old and new pre-tax retail price effectively taxes away these gains, which then accrue to the public sector.

$$\frac{T_M}{P_M^0} = -\frac{dP_S}{P_S} * (1 - \mu) - \frac{dm}{m} * \mu. \tag{4}$$

To estimate the resulting tax revenue, we also need to know the change in quantity in the new legal market (that is, the percentage change dQ_M/Q_M) – see equation (5) below. Legalization is expected to affect consumers' motivation to buy in the legal market, inducing a shift of original consumers from the informal market (self-growers) to the formal market, the entry of new consumers into the market due to the new possibility of buying cannabis legally ($\frac{dQ_{ML}}{Q_M} * Q_M$), and changes in consumption practices due to the change in the retail price $\left(\varepsilon^M * \frac{dP_M}{P_M^0}\right)$, where ε^M is the ordinary price elasticity of demand:

$$\frac{dQ_M}{Q_M} = \varepsilon^M * Q_M * \frac{dP_M}{P_M^0} + \frac{dQ_{ML}}{Q_M} * Q_M. \tag{5}$$

Since the price paid by end consumers in the new legal market is unaffected by design $\left(\frac{dP_M}{P_M^0} = 0\right)$ then only the expression $\frac{dQ_{ML}}{Q_M}$ is relevant from the above equation, where $\frac{dQ_{ML}}{Q_M}$ denotes the percentage change in the number of consumers in the commercial market due to the legalization of the market. New consumers may enter the legal market as they can purchase cannabis legally, but consumers from the informal market may also enter the new legal market as they were growing their own cannabis before legalization. This parameter is difficult to estimate but can be based on changes in consumption in countries where cannabis has already been legalized for personal use. We opted for an estimate based on the Canadian experience, see Section 2.2.2.