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Cannabis in the Swiss economy

Economic effects of current and alternate regulation in Switzerland

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CANNABIS IN THE SWISS ECONOMY. ECONOMIC EFFECTS OF CURRENT AND ALTERNATE REGULATION IN SWITZERLAND

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LIST OF ACRONYMS

AF	Attributable fraction
b	Billion
BetmG	Betäubungsmittelgesetz (narcotics law)
CBA	Cost-benefit-analysis
CE	Consumption expenditure
CHF	Swiss Francs
COI	Cost-of-illness
CSC	Cannabis Social Club
ESA	European System of Accounts
EFV	Eidgenössische Finanzverwaltung (Federal finance administration)
EU	European Union
EUR	Euro
FOPH	Federal Office of Public Health
FSO	Federal Statistical Office
FTE	Full Time Equivalent
GAAP	Generally Accepted Accounting Principles
GDP	Gross domestic product
GO	Gross output
GVA	Gross value added
ICD	International Statistical Classification of Diseases and Related Health Problems
IE	Income effect
IEA	Illegal economic activity

IFRS	International Financial Reporting Standards
II	Intermediate inputs
IIE	Intermediate input effect
IO	Input-Output
IOT	Input-Output-Table
JUSUS	Jugendstrafurteilsstatistik (youth crime sentencing statistic)
k	Kilo, thousand
LP	Labour productivity
m	Million
NOGA	Nomenclature Générale des Activités économiques (General Classification of Economic Activities)
NPT	Net product taxes / Net commodity taxes
NZ	New Zealand
PKS	Polizeiliche Kriminalstatistik (police statistic)
SNA	System of national accounts
StPO	Strafprozessordnung
SUS	Strafurteilsstatistik (crime sentencing statistic)
SVS	Strafvollzugsstatistik (statistic on the execution of sentences)
t	Tons
VAT	Value-added-tax

SUMMARY

Cannabis was first prohibited in Switzerland in 1951 (Bundesrat, 1951). Seventy years later, the world has changed, and many countries are discussing as to whether prohibition is a policy best suited to serve the public interest. Switzerland has been considering the question for decades now and multiple attempts have been made to change the form of regulation both in a stricter and in a more relaxed direction. This project aims to add an economic perspective to the debate, which has not been available in the past.

The first part of this study empirically investigates the economic effects associated with the current regulation of recreational cannabis in Switzerland. The analysis of the cannabis system includes the cannabis supply and demand (market), the healthcare system providing treatment and counselling of consumers, police activity related to the enforcement of narcotic laws, jurisprudence (court proceedings, prosecution, etc.), and court enforcement including prison sentences, monetary penalties and social work. To conduct the analysis, the most recent data available on the different segments of the cannabis system was compiled to estimate the economic effects associated with the current regulatory system by using an input-output-model for the Swiss economy. The model calculates both the direct economic effect, as well as indirect economic effects[1].

By collecting, analysing, and interpreting this data, this project constructed a holistic view on cannabis-related economic activity

[1] Economic multiplier effects (intermediate input effect and the income effect).

in Switzerland and provides an input for the ongoing debate on cannabis and drug regulation in Switzerland.

The second part of this project builds on the analysis in the first step and estimates the economic effects of alternative cannabis regulations. Simplified and stylized regulatory scenarios were constructed based on the experiences in other jurisdictions and available data for Switzerland. The scenarios were chosen with the aim to provide a comprehensive overview of the full width of economic working mechanisms.

The gross output[2] triggered by the current cannabis system in Switzerland is estimated at 1b CHF annually. This estimate includes both the direct effects of the cannabis market, healthcare, police, jurisprudence, and court enforcement segments as well as indirect economic effects triggered across the Swiss economy.

The annual revenue of the Swiss market for recreational cannabis is estimated at 582m CHF (including both marijuana and resin) and is based on the yearly consumption of 39.3 tonnes (t) of marijuana and 16.7t of resin. This corresponds to a little more than 750,000 joints daily, based on average consumption quantities per joint. More than 60% is consumed by very frequent users who consume cannabis on almost a daily basis.

Adjusting for imports, the annual gross output of the cannabis market amounts to 432m CHF on the direct level. The direct gross output of the other segments of the cannabis system amount to 14m CHF (court enforcement), 9m CHF (jurisprudence), 34m CHF (police), and 22m CHF (healthcare). Including indirect effects through intermediate inputs and generated incomes, the total effects (direct and indirect) amount to 843m CHF for the market segment, 44m CHF for healthcare, 71m CHF for the police, 18m CHF for jurisprudence and 23m CHF for court enforcement.

[2] Gross output measures industries sales to final demand (GDP) and to other industries. For most industries it corresponds to the total sales/revenue.

The total gross value added (GVA), the value generated by producing goods and services, for the cannabis system in Switzerland is estimated at 673m CHF of which 428m CHF are direct effects and 245m CHF are indirect. The direct value added generated by the cannabis system roughly corresponds to about 0.06% of Swiss GDP or to about half of the economy of the canton of Appenzell Innerrhoden. The closest industries in Switzerland with similar value added are water supply which is slightly smaller at 0.04% or the production of cars and car parts, which is slightly larger at 0.08%.

The total employment effect of the economic activity associated with the cannabis system amounts to about 4,400 full time equivalents. As a point of reference this is similar to the employment generated by the Swiss accident insurance (SUVA), which employs about 4,200 employees in Switzerland and the number of leadership positions at the city of Zurich (4,525).

The economic effects generated by the cannabis system trigger a total tax revenue1 of about 25m CHF including VAT and other net product taxes (e.g. tobacco, fuel) as well as income taxes.

The regulatory scenarios which were simulated in this project show that the economic effects of the cannabis system would change if alternative forms of regulation were applied. Three simplified and stylized scenarios were constructed and their economic effects estimated.

- The CSC scenario assumes legal consumption and possession for personal use as well as a non-commercial legalisation of cooperative production in taxed Cannabis Social Clubs.

- The High-Regulation scenario assumes a legal commercial market with far-reaching, public-health oriented regulation as well as a very high tax rate comparable to current retail prices in the illicit market.

- The Free-Market scenario alters the High-Regulation scenario by reducing cannabis-specific regulation to a minimum and not applying a product specific tax for cannabis products.

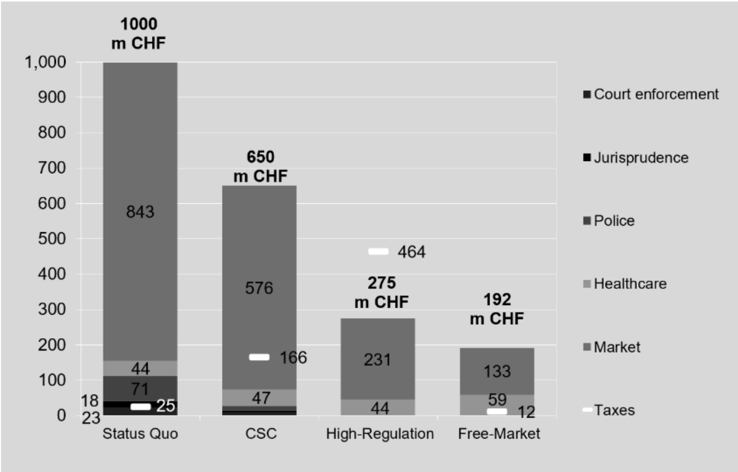
The simulation of the economic effects shows that the total gross output of the cannabis system could drop from 1b CHF annually in the status quo to just below 200m CHF in the Free-Market scenario. The Cannabis Social Club scenario would amount to about 650m CHF and the High-Regulation scenario would come it at about 275m CHF. The most influential factor for the reduction of gross output is the change in the legality of different activities related to cannabis across the scenarios. In the status quo 84% of total gross output consists of directly illegal activity (production, trade) or economic activity triggered by revenue generated from illegal activity. The reason for the size of this effect lies primarily in the very high profit margins caused by the illegality of cannabis.

The changes in gross output between the different scenarios are caused by multiple effects. One effect is the change in the quantity of economic processes in the cannabis system. As the effects for court enforcement, jurisprudence and police show, the total effects caused by these segments decreases between the status quo and the scenarios, because the economic activity previously triggered by the illegality of cannabis ceases to be necessary, when different aspects of cannabis become legal.

The second effect is that the value of the economic activity that remains changes, especially for the market segment due to a decrease in the mark-up for producing illegally and economies of scale. With decreases in production costs, profit margins and retail prices[3], the gross production of the cannabis market decreases.

[3] Depending on the taxation scheme.

Figure 1: Total gross output (dir. and indir.) and taxes for the status quo and scenarios (in m CHF)



A third effect, which feeds into the changes in gross output is the repatriation of economic activity from abroad. Whereas in the status quo and in the CSC scenario a share of consumption demand is provided through illegal imports from abroad, these quantities are domestically produced to different degrees in the regulation scenarios at prices, that are well below the illicit import value in the status quo.

A share of the decrease in gross output is captured as tax revenue in the regulatory scenarios. Whereas the status quo triggers a tax revenue[4] of about 25m without a legal market and without a product specific form of taxation, the CSC scenario would account for about 166m CHF in tax revenue[5] (using a price floor and revenue tax), the High-Regulation scenario for 464m CHF

[4] Including penalties and fines.
[5] Product taxes, which account for the largest share of the tax revenue in the regulatory scenarios are not part of gross output and thus need to be interpreted separately.

(using a weight and value based product tax as for tobacco) and the Free-Market scenario, which only includes VAT as a form of direct taxation, would amount to 11m CHF.

It is important to reiterate that these scenarios were *not* selected because they are necessarily considered sensible and prudent options from a regulatory perspective but rather because they cover a broad spectrum of different regulatory forms. The results, especially for the High-Regulation and Free-Market scenario, thus need to be interpreted as upper and lower boundaries and not as realistic predictions.

This project is based on available data in Switzerland and experiences and research from other jurisdictions which have recently changed their form of regulation. However, since there are significant limitations to the available data and the available methodologies using this data, these results must be interpreted cautiously in light of the limitations outlined in this study. If the policy discussions in Switzerland progress in the future and more data and insights from other jurisdictions become available, additional research is needed to refine the results.

Zusammenfassung

Cannabis ist in der Schweiz seit 1951 verboten (Bundesrat, 1951). Siebzig Jahre später hat sich die Welt verändert und viele Länder diskutieren offen darüber, ob die Prohibition als Regulierungsform dem öffentlichen Interesse am besten dient. In der Schweiz beschäftigt man sich ebenfalls seit Jahrzehnten mit dieser Frage und es wurden mehrfach Versuche unternommen, die Regulierung zu lockern oder zu verschärfen. Dieses Projekt zielt darauf ab, die ökonomische Perspektive dieser Diskussion mit Informationen zu bereichern, die bisher nicht vorhanden waren.

Der erste Teil der Studie untersucht die ökonomischen Effekte, die mit der aktuellen Regulierung von THC-haltigem Cannabis in der Schweiz verbunden sind. Die Analyse des Cannabissystems umfasst das Angebot und die Nachfrage nach Cannabis (Markt), das Gesundheitssystem, das die Behandlung und Beratung der Konsumenten sicherstellt, die polizeilichen Aktivitäten im Zusammenhang mit der Durchsetzung des Betäubungsmittelgesetzes, die Rechtsprechung (Gerichtsverfahren, Strafverfolgung usw.) und den Strafvollzug, einschliesslich Gefängnisstrafen, Geldstrafen und Sozialarbeit. Zur Durchführung der Analyse werden die aktuellsten verfügbaren Daten zu den verschiedenen Segmenten des Cannabissystems zusammengetragen und die mit dem derzeitigen Regulierungssystem verbundenen wirtschaftlichen Effekte mit Hilfe eines Input-Output-Modells für die Schweizer Wirtschaft geschätzt. Das Modell berechnet sowohl den direkten Effekt als auch die indirekten ökonomischen Effekte.

Der zweite Teil des Projekts untersucht aufbauend auf diesen Erkenntnissen die wirtschaftlichen Auswirkungen alternativer Cannabisregulierungen. Dazu werden Regulierungsszenarien konstruiert, die auf den Erfahrungen in anderen Ländern und für die Schweiz verfügbaren Daten basieren. Die Szenarien sollen einen möglichst umfassenden Überblick über die gesamte Breite der ökonomischen Wirkmechanismen geben.

Die durch das bestehende Cannabissystem in der Schweiz ausgelöste Bruttoproduktion wird auf 1 Mrd. CHF jährlich geschätzt. Diese Schätzung beinhaltet sowohl die direkten Effekte des Cannabismarktes, des Gesundheitswesens, der Polizei, der Rechtsprechung und des Strafvollzugs als auch die indirekten wirtschaftlichen Effekte, die in der gesamten Schweizer Wirtschaft ausgelöst werden.

Der jährliche Umsatz des Schweizer Marktes für Cannabis wird auf 582 Mio. CHF geschätzt (Marihuana und Haschisch) und basiert auf dem jährlichen Konsum von 39,3 Tonnen (t) Marihuana und 16,7 t Haschisch. Dies entspricht etwas mehr als 750.000 Joints pro Tag. Mehr als 60% werden von Konsumenten konsumiert, die fast täglich Cannabis konsumieren.

Bereinigt um Importe beträgt die jährliche Bruttoproduktion des Cannabismarktes auf der direkten Ebene 432 Mio. CHF. Die jährliche Bruttoproduktion der anderen Segmente des Cannabissystems beläuft sich auf 14 Mio. CHF (Strafvollzug), 9 Mio. CHF (Rechtsprechung), 34 Mio. CHF (Polizei) und 22 Mio. CHF (Gesundheits-wesen). Einschliesslich der indirekten Effekte durch Vorleistungen und generierte Einkommen belaufen sich die Gesamteffekte (direkt und indirekt) auf 843 Mio. CHF für das Marktsegment, 44 Mio. CHF für das Gesundheitswesen, 71 Mio. CHF für die Polizei, 18 Mio. CHF für die Rechtsprechung und 23 Mio. CHF für den Strafvollzug.

Die gesamte Bruttowertschöpfung (BWS), also der im Produktionsprozess geschaffene Mehrwert, wird für das Cannabissystem in der Schweiz auf 673 Mio. CHF geschätzt, wovon 428 Mio. CHF auf direkte und 245 Mio. CHF auf indirekte Effekte entfallen. Die direkte Wertschöpfung, die durch das Cannabissystem generiert wird, entspricht etwa 0,06 % des Schweizer BIP oder etwa der Hälfte der Wirtschaft des Kantons Appenzell Innerrhoden.

Vergleichbare Branchen in der Schweiz mit ähnlicher Wertschöpfung sind die Wasserversorgung, die mit 0,04 % etwas kleiner ist, oder die Herstellung von Autos und Autoteilen, die mit 0,08 % etwas grösser ist.

Der Gesamtbeschäftigungseffekt der mit dem Cannabissystem verbundenen wirtschaftlichen Aktivität beläuft sich auf etwa 4.400 Vollzeitäquivalente. Dies ist vergleichbar mit den Angestellten der Schweizerischen Unfallversicherung (SUVA), die in der Schweiz rund 4.200 Mitarbeiterinnen und Mitarbeiter beschäftigt, oder der Anzahl der Führungspositionen bei der Stadt Zürich (4.525).

Die durch das Cannabissystem generierten ökonomischen Effekte lösen ein Gesamtsteueraufkommen von ca. 25 Mio. CHF aus, das die Mehrwertsteuer und andere Gütersteuern (z.B. Tabak, Treibstoff) sowie die Einkommenssteuern beinhaltet.

Die in diesem Projekt simulierten Regulierungsszenarien zeigen, dass sich die ökonomischen Effekte des Cannabissystems verändern würden, wenn alternative Formen der Regulierung zur Anwendung kämen.

Es wurden drei vereinfachte Szenarien konstruiert und deren ökonomische Effekte abgeschätzt.

- Das CSC-Szenario geht von einem legalen Konsum und Besitz für den Eigenbedarf sowie einer nicht-kommerziellen Legalisierung von gemeinschaftlicher Produktion in besteuerten Cannabis Social Clubs aus.

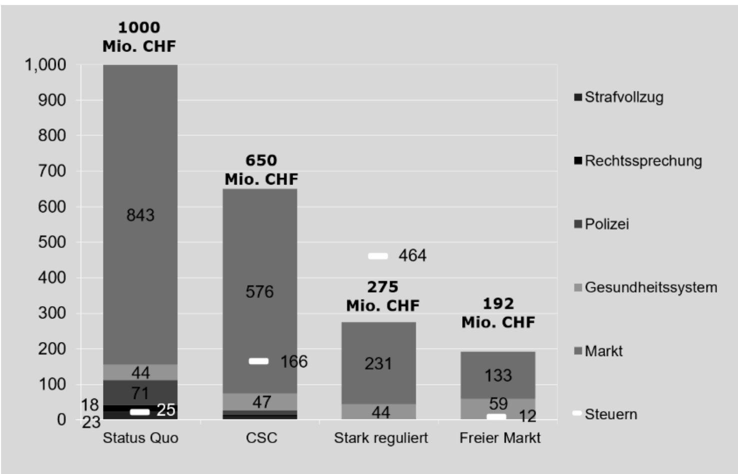
- Das Szenario „Stark-reguliert“ geht von einem legalen kommerziellen Markt mit einer weitreichenden, auf die öffentliche Gesundheit ausgerichteten Regulierung sowie einem sehr hohen Steuersatz aus, der zu einem Verkaufspreis in vergleichbarer Höhe zum aktuellen illegalen Markt führt.

- Das Szenario "Freier Markt" verändert das Szenario „Stark-reguliert“, indem es die cannabisspezifische

Regulierung auf ein Minimum reduziert und keine produktspezifische Steuer auf Cannabisprodukte erhebt.

Die Simulation der wirtschaftlichen Auswirkungen zeigt, dass die Bruttoproduktion (direkt und indirekt) des Cannabissystems von 1 Mrd. CHF jährlich im Status quo auf knapp 200 Mio. CHF im Szenario "Freier Markt" sinken könnte. Das Cannabis-Social-Club-Szenario würde sich auf ca. 650 Mio. CHF belaufen und das Szenario „Stark-reguliert" käme auf ca. 275 Mio. CHF. Der einflussreichste Faktor für die Reduktion der Bruttoproduktion ist die Veränderung der Legalität der verschiedenen Aktivitäten im Zusammenhang mit Cannabis in den drei Szenarien. Im Status quo bestehen 84 % der gesamten Bruttoproduktion aus direkt illegalen Aktivitäten (Produktion, Handel) oder aus wirtschaftlichen Aktivitäten, die durch Einnahmen aus illegalen Aktivitäten ausgelöst werden. Der Grund für die Grösse dieses Effekts liegt vor allem in den sehr hohen Gewinnspannen, die durch die Illegalität von Cannabis entstehen.

Figure 2: Bruttoproduktion (dir. und indir.) und Steuerertrag im Status Quo und den Regulierungsszenarien (in Mio. CHF)



Die Unterschiede in den berechneten Szenarien werden durch verschiedene Effekte hervorgerufen: Ein Effekt entsteht durch die Veränderung der ökonomischen Prozesse im Cannabissystem. In den Segmenten Strafvollzug, Rechtsprechung und Polizei nimmt dieser Effekt zwischen dem Status quo und den Szenarien ab, weil die zuvor durch die Illegalität von Cannabis ausgelöste wirtschaftliche Aktivität entfällt, wenn verschiedene Aspekte von Cannabis legal werden.

Der zweite Effekt ist, dass sich der Wert der verbleibenden wirtschaftlichen Aktivität ändert, aufgrund eines Rückgangs der Gewinnmarge für die illegale Produktion und aufgrund von Skaleneffekten in der Produktion. Mit sinkenden Produktions-kosten, Gewinnmargen und Verkaufspreisen sinkt die Bruttoproduktion des Cannabismarktes ebenfalls.

Ein dritter Effekt, der in die Veränderungen der Bruttoproduktion einfliesst, ist die Rückführung der wirtschaftlichen Aktivität aus dem Ausland. Während im Status quo und im CSC-Szenario ein Teil der Konsumnachfrage durch illegale Importe aus dem Ausland gedeckt wird, werden diese Mengen in den Regulierungsszenarien zu unterschiedlichem Grad im Inland produziert, und zwar zu Preisen, die deutlich unter dem Importwert der illegalen Importe im Status quo liegen.

Ein Teil des Rückgangs der Bruttoproduktion wird in den Regulierungsszenarien als Steuereinnahmen abgeschöpft. Während der Status quo ohne legalen Markt und ohne produktspezifische Besteuerung ein Steueraufkommen von ca. 25 Mio. CHF auslöst, würde das CSC-Szenario (mit Preisuntergrenze und Umsatzsteuer) ein Steueraufkommen von ca. 166 Mio. CHF, das Szenario „Stark-reguliert“ (mit einer gewichts- und wertbasierten Produktsteuer ähnlich wie Tabak) von 464 Mio. CHF und das Szenario "Freier Markt", das nur die Mehrwertsteuer als Form der direkten Besteuerung vorsieht, von 11 Mio. CHF ausmachen.

Es ist wichtig zu beachten, dass diese Szenarien nicht ausgewählt worden sind, weil sie aus regulatorischer Sicht als vernünftige und umsichtige Optionen angesehen werden, sondern weil sie ein breites Spektrum verschiedener Regulierungsformen abdecken. Die Ergebnisse, insbesondere für das Szenario „Stark-reguliert“ und "Freier Markt", müssen daher als obere und untere Grenzen und nicht als realistische Prognosen interpretiert werden.

Dieses Projekt basiert auf den in der Schweiz verfügbaren Daten sowie auf Erfahrungen und Forschung aus anderen Ländern, die ihre Regulierungsform kürzlich geändert haben. Da die verfügbaren Daten und auch die angewandte Methodik der Szenarienanalyse erhebliche Einschränkungen aufweisen, müssen die Ergebnisse vorsichtig interpretiert werden. Wenn die politische Diskussion in der Schweiz in Zukunft fortschreitet und mehr Daten und Erkenntnisse aus Ländern verfügbar werden, sind zusätzliche Untersuchungen sinnvoll, um die Ergebnisse zu verfeinern.

RÉSUMÉ

En Suisse le cannabis a été interdit pour la première fois en 1951 (Bundesrat, 1951). Soixante-dix ans plus tard, le monde a changé et de nombreux pays discutent publiquement si la prohibition du cannabis est la réglementation la mieux adaptée pour servir l'intérêt public. Depuis plusieurs décennies, la Suisse se penche sur cette question et de multiples tentatives ont été faites, parfois pour alléger, parfois pour durcir la réglementation Le présent projet vise à ajouter une nouvelle perspective économique et de nouvelles informations au débat.

La première partie de cette étude examine empiriquement les effets économiques associés à la réglementation actuelle du cannabis récréatif en Suisse. L'analyse du système du cannabis comprend l'offre et la demande de cannabis (marché), le système de santé qui assure le traitement des et le conseil aux consommateurs, l'activité de la police liée à l'application des lois sur les stupéfiants, la jurisprudence (procédures judiciaires, poursuites, etc.), et l'application des tribunaux, y compris les peines de prison, les sanctions monétaires et le travail social. Afin d'estimer les effets économiques associés au système réglementaire actuel, l'analyse se base sur les données les plus récentes disponibles sur les différents segments du système du cannabis. Ces données ont été compilées en utilisant un modèle input-output pour l'économie suisse. Le modèle calcule à la fois l'effet économique direct et les effets économiques indirects.

La deuxième partie de ce projet s'appuie sur l'analyse de la première étape et estime les effets économiques de réglementations alternatives du cannabis. Des scénarios réglementaires simplifiés ont été construits sur la base des expériences d'autres juridictions

et des données disponibles pour la Suisse. Les scénarios ont été choisis dans le but de fournir un aperçu complet de l'éventail des mécanismes de fonctionnement économique.

La production brute déclenchée par le système actuel du cannabis en Suisse est estimée à 1 milliard de francs suisses par an. Cette estimation comprend à la fois les effets directs du marché du cannabis, des soins de santé, de la police, de la jurisprudence et des segments d'exécution des tribunaux, ainsi que les effets économiques indirects déclenchés dans l'ensemble de l'économie suisse.

Les revenus annuels du marché suisse du cannabis récréatif sont estimés à 582 millions de CHF (marijuana et résine comprises) et sont basés sur la consommation annuelle de 39,3 tonnes (t) de marijuana et 16,7 t de résine. Cela correspond à un peu plus de 750 000 joints par jour. Plus de 60 % de la consommation reviennent aux usagers très fréquents consommant du cannabis de façon quasi quotidienne.

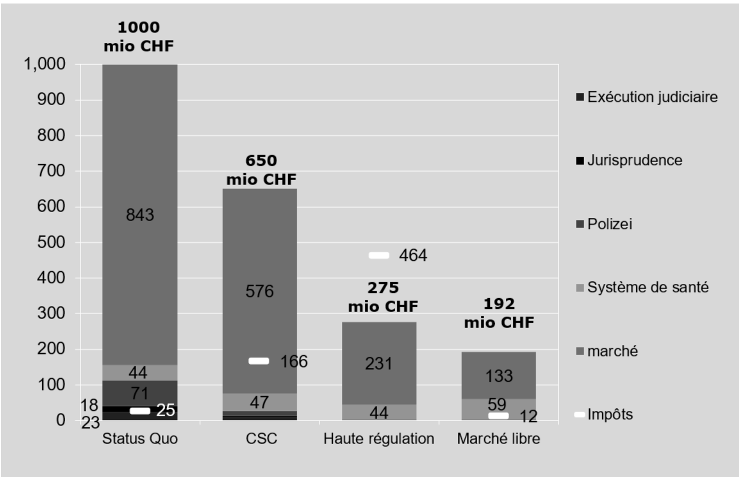
En tenant compte des importations, la production brute annuelle du marché du cannabis s'élève à 432 millions de CHF au niveau direct. La production brute directe des autres segments du système du cannabis s'élève à 14 millions de CHF (application des lois), 9 millions de CHF (jurisprudence), 34 millions de CHF (police) et 22 millions de CHF (soins de santé). En incluant les effets indirects par le biais des intrants intermédiaires et des revenus générés, les effets totaux (directs et indirects) s'élèvent à 843 millions de CHF pour le segment du marché, 44 millions de CHF pour les soins de santé, 71 millions de CHF pour la police, 18 millions de CHF pour la jurisprudence et 23 millions de CHF pour l'application des lois.

Le scénario CSC suppose une consommation et une possession légales pour un usage personnel ainsi qu'une légalisation non commerciale de la production coopérative dans des Cannabis Social Clubs taxés.

Le scénario de « haute réglementation » suppose un marché commercial légal avec une réglementation considérable et orientée vers la santé publique, ainsi qu'un taux d'imposition très élevé conduisant à un prix de vente d'un montant comparable par rapport aux prix de détail actuels sur le marché illicite.

Le scénario de « marché libre » modifie le scénario de haute règlementation en réduisant au minimum la réglementation spécifique au cannabis et en n'appliquant pas de taxe spécifique aux produits de cannabis.

Figure 3: Production brute totale (dir. et indir.) et taxes pour le statu quo et les scénarios (en mio CHF)



La simulation des effets économiques montre que la production brute totale du système du cannabis pourrait passer de 1 milliard de francs suisses par an dans le statu quo à un peu moins de 200 millions de francs suisses dans le scénario du marché libre. Le scénario du Cannabis Social Club s'élèverait à environ 650 millions de CHF et le scénario de la Haute Réglementation à environ 275 millions de CHF. Le facteur le plus influent sur la réduction de la production brute est le changement de la légalité des différentes activités liées au cannabis dans les différents scénarios. Dans le statu quo, 84% de la production brute totale consiste en une activité directe et illégale (production, commerce) ou en une activité économique déclenchée par les revenus générés par l'activité illégale. L'ampleur de cet effet s'explique principalement par les marges bénéficiaires très élevées engendrées par l'illégalité du cannabis.

Les variations de la production brute entre les différents scénarios sont dues à de multiples effets. L'un des effets est le changement de la quantité de processus économiques dans le système du cannabis. Comme le montrent les effets pour l'application des lois, la jurisprudence et la police, les effets causés à l'intérieur de ces segments diminuent entre le statu quo et les scénarios car l'activité économique précédemment déclenchée par l'illégalité du cannabis disparait lorsque différents aspects du cannabis deviennent légaux.

Le deuxième effet est que la valeur de l'activité économique qui subsiste change, en particulier pour le segment du marché en raison d'une diminution de la marge bénéficiaire pour la production illégale et des économies d'échelle. Avec la baisse des coûts de production, des marges bénéficiaires et des prix de détail[6] , la production brute du marché du cannabis diminue également.

Un troisième effet qui provoque des changements dans la production brute est le rapatriement de l'activité économique de l'étranger. Alors que dans le statu quo et dans le scénario CSC les importations illégales de l'étranger couvrent une partie de la demande de consommation, ces quantités sont produites au niveau national à des degrés divers dans les scénarios de réglementation. Notamment, elles sont produites à des prix bien inférieurs à la valeur des importations illicites dans le statu quo.

Dans les scénarios de régulation, la recette fiscale absorbe une partie de la diminution de la production brute. Alors que le statu

[6] En fonction du régime d'imposition.

quo déclenche des recettes fiscales[7] d'environ 25 millions sans marché légal et sans forme de taxation spécifique au produit, le scénario CSC représenterait environ 166 millions de CHF de recettes fiscales[8] (en utilisant un prix plancher et une TVA), le scénario de haute réglementation 464 millions de CHF (en utilisant une taxe sur les produits basée sur le poids et la valeur comme pour le tabac) et le scénario de marché libre, qui n'inclut que la TVA comme forme de taxation directe, s'élèverait à 11 millions de CHF.

Il est important de rappeler que ces scénarios n'ont pas été choisis parce qu'ils sont nécessairement considérés comme des options judicieuses et prudentes d'un point de vue réglementaire, mais plutôt parce qu'ils couvrent un large éventail de différentes formes réglementaires. Les résultats, en particulier pour les scénarios de haute réglementation et de marché libre, doivent donc être interprétés comme des limites supérieures et inférieures et non comme des prévisions réalistes.

Ce projet est basé sur les données disponibles en Suisse et sur les expériences et recherches d'autres juridictions qui ont récemment changé leur forme de régulation. Les données disponibles et les méthodologies disponibles utilisant ces données présentent des limites importantes. Par conséquent ces résultats doivent être interprétés avec prudence et en tenant compte des limites soulignées dans ce rapport. Si les discussions politiques en Suisse progressent à l'avenir et si davantage de données et d'informations provenant d'autres juridictions sont disponibles, des recherches supplémentaires seront nécessaires pour affiner les résultats.

[7] Y compris les pénalités et les amendes.
[8] Les taxes sur les produits, qui représentent la plus grande part des recettes fiscales dans les scénarios réglementaires, ne font pas partie de la production brute et doivent donc être interprétées séparément.

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Conflict of interest Statement

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Chapter 1: Introduction

During the 20th century cannabis as a drug was prohibited in most of the countries around the world (Bewley-Taylor et al., 2014; Collins, 2020; Wodak, 2012). This is also true for Switzerland, where cannabis was first prohibited in 1951 (Bundesrat, 1951). However, the way cannabis is regulated around the world has started to shift (Kilmer, 2017; Zobel & Marthaler, 2016). Given the wide spectrum on interests and perspectives on cannabis regulation there is no single discipline that can provide a sufficient basis for a holistic answer to the question how cannabis should be regulated. This is also true for economics.

Nonetheless, economics is – in one of its definitions – the study of how people and institutions choose to allocate scarce resources (American Economic Association, 2019). Since all activities connected to cannabis are related to the use of both private and public resources, economics thus connects to all other perspectives on the regulation of cannabis and cannot be disregarded when trying to provide meaningful information for any political decision on how cannabis ought to be regulated.

This project deals with this economic dimension of recreational cannabis use in Switzerland. The first part of this study empirically investigates the economic effects associated with the current regulation of recreational cannabis in Switzerland. The second part of this project builds on the analysis of the status quo and estimates the economic effects of different forms of alternative regulations for cannabis.

There are many research papers that deal with individual aspects of the cannabis system. However, the economic cannabis system in Switzerland comprises a number of interlinked activities and actors that are all relevant for understanding the system in its entirety. On the one hand, these have a direct economic relevance. On the other hand, various links exist between the cannabis system and the rest of the economy that are commonly termed as indirect and induced impacts. Disregarding these economic effects would leave an economic analysis incomplete.

To understand how the current regulatory situation affects the Swiss economy it is thus necessary to distinguish carefully between activities, actors, and direct and indirect effects, as well as between legal and illegal activities. This not only allows decision makers to interpret and discuss the results on a more detailed basis, but also provides information on the distinction between individual and social costs, as well as economic effects in other parts of the economy.

There is little information on the current economic dimension of cannabis in the Swiss economy and the potential economic effects of changes in the regulation of cannabis. This project aims to provide part of the needed information.

The problem is approached by first formulating the dimension of the economic (recreational) cannabis system[9] in Switzerland and then estimating its direct economic effects. Subsequently, the extent of the indirect economic dimension of the cannabis system is calculated in the Swiss economy in terms of output, gross value added, employment and tax revenue. This will be done using a static open input-output model that quantitatively depicts the flow of goods and services between industries and from industries to final demand (household and government consumption, capital formation, and exports; see chapter 4.1). Analysing the cannabis

[9] When talking about the economic cannabis system in Switzerland (short: cannabis system), I mean all economic activities in Switzerland that are directly related to the recreational usage of cannabis. This includes, but is not limited to: production, distribution and trade, im- and export, consumption (the entire value-chain of cannabis) as well as cannabis related activities in health care and the justice system (police, jurisprudence, court system, court enforcement).

system using this approach allows not only for a comparison of the economic effects of the cannabis system on Swiss GDP, but also enables for comparison with other countries.

To analyse the economic impact of alternative forms of regulation in Switzerland regulatory scenarios will be developed. Subsequently the scenarios will be combined with data on the effects of individual regulatory variables upon the cannabis system to be able to estimate the combined effects of each scenario. The last step of this research project will be the approximation of the full economic effect that the scenarios would have for Switzerland. It is important to note, that the regulatory scenarios created in this project are stylized devices to simulate mechanisms that can show how supply- and demand-side regulation works. They contain numerous regulatory variables but are not meant to adequately estimate the precise effect of concrete forms of regulation. To do so would require significantly more data than is currently available, the current situation in Switzerland, and the effect of different forms of regulation.

This project uses a positive analytic approach in contrast to a normative approach. It will thus neither answer the question of how cannabis should be regulated (from an economic standpoint) nor judge the current or alternative regulatory systems. It instead provides an economic analysis of the status quo and uses a counterfactual analysis to study potential alternatives. The outcome of this analysis will thus be a differentiated view on the current economic dimension of cannabis in Switzerland and what it would mean, in economic terms, if regulation were changed in one way or another. The following research questions will be addressed in this project:

- What are the total economic effects on both the direct and indirect levels triggered by the cannabis system in the Swiss economy?
- How are these effects split between different actors, processes, and legal and illegal activity?

- What are relevant economic regulatory variables for recreational cannabis and what are the extents of their effects when combined in regulatory scenarios?

They are selected for three reasons. First and foremost, there is a research gap concerning the economic dimension of recreational cannabis in Switzerland, as shown in chapter 4.2. Secondly, there is a considerable dynamic in regulatory approaches to cannabis in other jurisdictions around the world providing some insights into the potential quantitative effects of regulatory changes. Thirdly the topic of cannabis regulation has attracted both public and political attention and sparked ample discussion over the last decades.

The goal of this project is thus to provide transparent information on the current economic situation of cannabis in Switzerland, and to provide insight into the economic working mechanism of supply- and demand-side regulation in counterfactual regulatory scenarios. I intend this to act as input for the discussion of the future of cannabis regulation in Switzerland for both policy makers and the interested public.

The experience of several decades of prohibition, a changing public perception of cannabis, as well as a growing body of research criticizing the rationale, effects and effectiveness of prohibitive regulation has led a growing number of countries to rethink and re-evaluate their regulatory approaches towards cannabis.[10] The situation in Switzerland reflects this international trend. Since the implementation of the so-called "four pillar principles" (see Federal Office of Public Health FOPH (2021) for the inclusion of harm-reduction as a fourth pillar) to tackle the widespread usage of heroin and cocaine in the 1980s, the Swiss public has had

[10] An extensive review on the history of international cannabis regulation has been conducted by Bewley-Taylor et al. (2014). A Summary of regulation regimes in place (including recent changes) is provided by Eastwood et al. (2016) and Kilmer (2017).

regular discussions and plebiscites[11] on the regulation of illegal drugs, including cannabis. With little changes to the general regulatory approach towards cannabis (and other, similar substances) the prevailing prohibitive regulatory model appears to be more and more in conflict to a continuous change in the publics' perception and behaviour (Cattacin, 2012). Recent changes in cannabis regulation or discussions thereof in other countries[12] have reignited this controversial discussion in Switzerland. This project is linked to this debate because it tries to shed light on one of the topics, which is relevant for both the understanding of the Swiss cannabis economy as well as the effects of potential regulation alternatives.

Derived from the research questions presented in the previous chapter there are several subtopics, that will be addressed. Due to the wide array of questions that this project deals with, in combination with the different regulatory approaches worldwide, the relevant body of literature for this project is large. Rather than organizing it on a country-by-country basis, I have decided on a topic-by-topic approach. The literature review on each subtopic is placed into the following chapters describing the methodology and results of this project. Arranging the study in this way rather than separating the literature review from the content of this project enables the reader to quickly connect both the original work of this project with the state of research on the various topics.

[11] E.g. the 1997 plebiscite „Youth without drugs" (29.3% yes) calling for a very restrictive regulation, the 1998 plebiscite „for a sensible drug policy" (26% yes) calling for a decriminalization of drug use and a federally regulated market for illegal drugs and the 2008 plebiscite "for a sensible cannabis policy including youth prevention" (37% yes).

[12] E.g. several States in the USA, Uruguay, Australia, Canada.

CHAPTER 2: ILLEGAL ACTIVITIES AND ECONOMIC STATISTICS

Over the course of the last century, national accounting – the science of measuring the economic activity of a country or a people – has developed at a steady pace. Based on national accounts, it is today often quick and easy to make differentiated and relatively reliable economic comparisons between countries. By combining data on firms, employees, households, production, income and expenditures a standardized accounting system was set up internationally (United Nations et al., 2009), that allows country-by-country comparisons. In Europe, this system is called the "European System of Accounts" (ESA), which is regularly adapted to follow the continuous development of the United Nations Systems of National Accounts (SNA). While these accounts have made great progress for understanding, analysing and comparing economic phenomenon, they have also been discussed controversially (Stiglitz et al., 2009). One of the core arguments of the critique by Stiglitz et al. is: "*What we measure affects what we do; and if our measurements are flawed, decisions may be distorted*" (ibid, p. 7). While this critique has broader meaning in the context of the national accounts debate, in this analysis it is relevant because illegal economic activity (IEA), under which illegal drug consumption, production and trafficking falls, has – amongst other things (such as unpaid work) – not been included in national accounts for a long time. Since the non-observed economy, of which IEA are a part, can make up a significant proportion of national economic activity (F. Schneider & Klinglmair, 2004), the critique above is highly relevant with reference to the case of illegal drugs and economic statistics.

One of the cornerstones of statistics is the attempt to describe reality as closely as possible. Since the representation of de-facto existing activity has, statistically speaking, a higher priority than the legality of these activities when it comes to economic statistics, national accountants and statisticians have suggested to include measures of IEA into the SNA/ESA framework. National accounting concepts have stipulated including illegal activities such as production and trade of drugs, smuggling of cigarettes and prostitution in the calculation of a country's GDP since at least the 1993 SNA (Havinga et al., 2006). The OECD in their handbook on measuring the non-observed economy notes:

> "[…] the 1993 SNA explicitly states that productive illegal activities should be included in national accounts. There are several reasons for this. The 1993 SNA emphasises the need for overall consistency. 'Clearly, the accounts as a whole are liable to be seriously distorted if monetary transactions that in fact take place are excluded.' (SNA 1993: 3.54.) Not taking illegal activities fully into account gives rise to discrepancies in the accounts. The incomes earned from illegal production are largely spent on the purchase of legal goods and services, on the acquisition of legal fixed or financial assets or other legal transactions. Since all these transactions are recorded in the accounts along with those that are financed by incomes from legal activities, there is inevitably a discrepancy between supply and uses for the economy as a whole if the production and imports of illegal goods and services are omitted." (p. 8)

This is especially relevant since the legality of different economic activities can change over time and from country to country. Not accounting for economic activity, that de-facto occurs, but is illegal at a given time in a given country or region would thus distort any statistic, which aims to capture the entirety of economic activity, especially when comparing it to similar statistics in other countries where said economic activity might be legal. Starting in September 2014, EU Member states have thus agreed to include "*illegal prostitution, the production and trafficking of illegal drugs,* *and the smuggling of tobacco and alcohol products*" into the measurement of EU member states' economic activity (Eurostat, 2018, p. 3). With the change from ESA 95 to ESA 2010, countries in the EU now must include illegal activities on a mandatory basis. Since illegal production, which includes the production and distribution of illegal drugs is included in these illegal activities, the Swiss Federal Statistical Office (FSO) is currently adapting the Swiss System of National Accounts to comply with this change and includes drug production and trade in the calculation of GDP (Federal Statistical Office, 2020c).

If the economic effects of the cannabis system are to be compared with national accounting statistics, it is crucial, to conduct the analysis in a way, that allows for exactly this comparison. For this reason, I have separated the aggregated economic effects of the cannabis system into their respective economic components (see chapter 4.2) in order to adequately reflect the actual share of cannabis related economic activity to the national accounts. To do so, it is first necessary to both structure and quantify the individual segments of the cannabis system, which will be described in more detail in the subsequent chapter.

CHAPTER 3: ESTIMATING THE CANNABIS SYSTEM IN SWITZERLAND

This chapter first discusses different methodologies for the analysis of the economic side of cannabis and in a second step outlines the methodology and data used for the quantification of the five segments of the cannabis system in the corresponding subchapters (market, healthcare and treatment, police, jurisprudence and execution of sentences).

Quantifying the economic cannabis system in Switzerland poses two challenges. Due to the illegality of cannabis containing more than 1% tetrahydrocannabinol (THC) in Switzerland, there is very little official statistical information available on most topics related to cannabis compared to alcohol or tobacco for example. Additionally, the illegality influences the quality of data that is available, specifically survey data on consumption prevalence. It is well documented that the social stigma associated with illegal drug use as well as potential legal consequences cause people to underreport their usage or conceal it altogether (Harrison et al., 2007, p. 76; Kilmer et al., 2013, p. 12; Kilmer & Pacula, 2009, p. 13). To address these data-quality and -availability issues, the estimations of the various subtopics within the cannabis system depend on several assumptions that are based on various quantitative and qualitative data sources. Since the quality and validity of these assumptions can vary, hereinafter I describe the approaches that were used for reaching these assumptions to make it transparent where the results are sensitive to changes in the assumptions.

3.1 METHODOLOGICAL CONSIDERATIONS

When analysing the phenomenon of cannabis usage and/or regulation a number of different methodologies are applied, depending on the research question, data sources and perspective of the analysis. Schmidhauser & Zobel (2021) provide a very contemporary review of the existing literature with respect to the cases in the United States, Canada and Uruguay. When only focusing on research that attempts to quantify economic issues related to cannabis regulation, there are; amongst others, three main ways to do so.

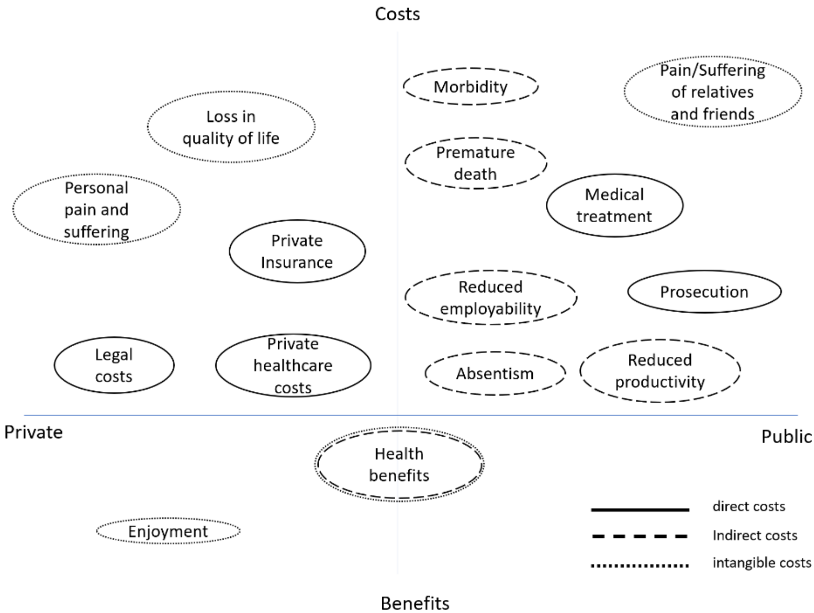
The first is a cost-benefit analysis (CBA) [13], that tries to quantify both costs and benefits (private and public) of cannabis regulation and aims to estimate a net-effect for both the private and public perspective (Kinderen & Rombouts, 2018; Shanahan et al., 2017; Shanahan & Ritter, 2014; van Dijk, 1998). In other words, the goal of this methodology is to establish, whether the costs of a particular form of regulation outweighs the benefits from a public (societal) or private (individual) perspective.

The second approach is called "social-costs" and aims to differentiate primarily between privately and publicly incurred costs of activities associated with cannabis consumption. The underlying aim of this approach is to estimate the *costs to society of a particular phenomenon (here cannabis usage)*. The reason why private costs are discounted in this methodology is usually based on the underlying argument, that privately incurred costs on the one side are, given rational decision making, less or equal, to privately gained utility (G. S. Becker & Murphy, 1988; D. M. Walker & Barnett, 1999) and on the other hand, they are, as the name suggests, private and thus of little concern when thinking about public resource allocation. When related to illnesses, this method is called the cost-of-illness (COI) or burden of disease (BOD) (Hodgson & Meiners,

[13] Cost effectiveness analysis is a similar methodology where the general research question is what output is generated with a particular input and/or, how would this change if the input were to change

1982; Jo, 2014; Rice, 1994) and is used widely to estimate *"the total burden of a particular disease to society"* (Byford et al., 2000). It is worth mentioning though, that while the general concept of the COI methodology is well defined, there are significant differences in the implication. Verhaeghe et al. (2017, p. 5) summarise the findings of 12 contemporary studies using this methodology and show, how they differ with respect to the various aspects they include (e.g. rehabilitation, homecare, prevention, education, etc.).

Figure 3: Issues related to recreational cannabis distinguished between costs/benefits and private/public from the perspective of the cost-of-illness methodology[14]



[14] Translated and reproduced with kind permission from Fischer, Mäder, et al. (2020).

Because the aim of this methodology is to quantify the burden of a disease to society, it only includes public costs by definition (see the right side of figure 4). It includes not only direct public costs, but also *indirect* and *intangible costs* such as premature death, reduced productivity or the suffering of friends and relatives insofar as these can be monetarised. By including indirect and intangible costs (in the COI definition), the method does not only capture "what is", but it also tries to quantify "what would have been" in the sense of lost output due to effects of the illness such as for example reduced productivity.

While this perspective on calculating the burden of illnesses makes sense, when looking at it primarily from a public health perspective, it has two drawbacks for the purpose of this study. One the one side, calculating indirect and intangible effects means capturing economic activity, that did *not* occur because of the disease under investigation which is not comparable to the national accounting approach of capturing what economic activity *does* occur. On the other side, since this methodology - by design - only focus on the public costs, it does not capture *all* economic activity, related to cannabis in Switzerland. Major aspects such as the cannabis market, private healthcare cost, private legal costs, etc. are not captured by this approach. Especially when considering regulatory questions however, it is necessary to include these economic activities into the analysis, because regulation can and does impact all economic activity (both public and private) and changes the line between private and public costs.

For Switzerland, there are two studies that have used the social cost approach which relate directly to cannabis (Fischer, Mäder, et al., 2020; Jeanrenaud et al., 2005). However, the focus for both studies is not cannabis in particular, but illegal drugs overall for Jeanrenaud et al., and addiction in general for Fischer et al. (including illegal drugs).

The third approach, which is the one this paper follows, does neither try to compare costs and benefits, nor does it only focus on private or public costs but rather includes both. Its primary focus is to capture *all economic activity associated with the current form of regulation and consumption of cannabis* with a statistical focus regardless of whether these effects constitute costs and/or benefits and regardless of whom they apply to. This means, I capture economic effects, as they would be captured in national accounting, to be able to determine, what the overall dimension of economic effects associated with cannabis is and to be able to compare it to other forms of economic activity (e.g., different industries or the GDP). This study thus does not distinguish between private and public economic effects, nor does it include indirect or intangible effects, *as they are defined in the COI/BOD methodology*.

It is important to note, that the COI/BOD methodology and the methodology used in this study have two different aims. Whereas the COI/BOD methodology aims to calculate the gross costs of a particular disease/phenomenon to society, the methodology of this study aims to capture the full economic effects associated with all economic activity related to cannabis, regardless of whether they constitute a societal cost or not as this information is required for regulatory considerations in the future. While both methodologies appear similar, and to a certain extent rely on the same data, their results need to be interpreted individually and not in direct comparison.

This project does calculate indirect economic effects, but the indirect effects in this methodology relate to additional economic activity that is triggered throughout the economy, by the activities related to cannabis. These are indirect effects such as economic activity generated by additional incomes or through the supply chain of cannabis related economic activity. It is important not to mistake these indirect effects for the indirect effects of the COI/BOD methodology.

3.2 THE STRUCTURE OF THE CANNABIS SYSTEM IN SWITZERLAND

This study estimates different economic activity related to cannabis as a recreational drug. It is broadly structured into five different topics:

- Cannabis market
- Healthcare and treatment
- Police
- Jurisprudence
- Court enforcement

The cannabis market includes all activities that are related to the production, import, processing, and trade of cannabis products. This includes both commercial activity as well as private production and consumption.

The healthcare and treatment topic covers activities that are related to the treatment and/or psychosocial assistance of cannabis consumers for cannabis related issues. This includes for example the treatment of cannabis intoxications and therapeutical and psychosocial counselling in institutions focused on the treatment of addictions. Activities related to primary, secondary, or tertiary prevention have not been included, unless they are integral part of the treatments (see chapter 3.2).

Police activity with regards to cannabis covers the enforcement activities of the various police forces in Switzerland in response to the current regulation and following policing strategy. This includes but is not limited to drug checks during patrol, reporting people for misdemeanours, investigating suspects, as well as proactively investigating production and trade operations. Internal administrative processes like filing, archiving, analytics, and evidence management is also included in the estimate. It also includes activities of the border patrol who are responsible for securing both land and air-routes into the country. The seizures that police forces make during their operations are also included in the market estimate and are further dissected depending on the type and size of the seizure.

Once cases have been investigated, it is up to the judiciary to prosecute and judge the cases and, when found guilty, sentence the perpetrators to adequate punishments based on current narcotics law. The economic activity of public prosecutors and judges, as well as other related jobs and activities that are required to process the cases is estimated in the jurisprudence segment of the cannabis system.

Finally, the court enforcement segment includes all economic activity, that deals with enforcing court mandated sentences. This includes prison sentences, juvenile detention centres, monetary penalties, fines and mandated social work sentences.

3.3 CAUSALITY

For each of these topics it is essential to establish causality between the economic activity and the current cannabis system. Only if economic activity is triggered by the current cannabis system (this includes regulation, enforcement, and consumption), it is included in the estimation. Two guiding questions help to determine whether an economic activity should be included, or not:

- Would this activity take place if there was no demand for cannabis?
- Is this activity caused by the current regulation of cannabis in Switzerland?

A simple example, that helps to distinguish between what is included and what is not are police vehicle checks. There are some vehicle checks, where the police find cannabis on a driver or in a vehicle. This does not mean however, that the effort for all vehicle checks needs to be included in this analysis, since traffic stops are a general occurrence and are only partially attributed to enforcing narcotics law. They would almost certainly also be conducted if cannabis were regulated differently - even though potentially with a different focus and intensity. Nonetheless, the activity which is triggered by finding cannabis on a driver/in a vehicle is clearly caused by the current regulation of cannabis. A report is created, a fine might be imposed or a case might be opened for further investigation. This activity needs to be considered, as it is directly caused by both the consumption/existence of cannabis in Switzerland and the current form of regulation.

While this example explains the general rule of thumb, that was used to establish causality, the application of the rule is not always as black and white. This is the case, because it is not always possible to distinguish between activity that is triggered directly by cannabis and regulation and activity that is not. To make it as transparent as possible what activity is included and why, each subchapter outlines which activity is included, which is not, and what the limitations of the available quantitative and qualitative data is.

3.4 CANNABIS MARKET

The first of the five segments of the cannabis system which is analysed in this project is the cannabis market. The supply and demand of recreational cannabis plays a large role in the overall economic effects and is thus the first topic described in detail in this chapter.

To estimate the dimension of the cannabis system in Switzerland, it is important to estimate the total volume of cannabis that is consumed in Switzerland in any given year (total consumption demand) as well as the supply chain associated with the final product (production and trade). This information, along with additional data on consumption patterns, products, prices, production processes, etc. allows for a thorough and differentiated view at the cannabis economy in Switzerland and provides the basis for both the estimation of the current regulatory situation as well as the effects of possible alternatives.

Due to the illegality of cannabis in Switzerland, there are limitations to the quality of this estimate. During the work on this project several factors had no quantitative basis and thus had to be approximated given available data from other countries/jurisdictions. Some projects in other countries have decided to approach similar estimations by using bandwidths estimations (Hajizadeh, 2016; Haucap et al., 2018; Kilmer et al., 2013; Kilmer, Sohler Everingham, et al., 2014; Kilmer & Pacula, 2009; Zobel et al., 2020) and Eurostat and the OECD set forth similar guidelines (Eurostat, 2018; OECD, 2002). However, during the project it became apparent, that in most cases, there is no or little reliable information on the deviation of individual variables and the selection of bandwidths would often have been arbitrary. Therefore, I decided to conduct this estimation as a point estimate, rather than as a bandwidth approximation. To ensure that the inherent uncertainty in specifical data sources and variables is transparent and the sensitivity of the results is accounted for, a sensitivity analysis is conducted in Chapter 6.

Using a point estimate does not mean, that the estimation in this project is more precise than other approaches. It has the same limitations as a bandwidth-approach but acknowledges the limitations of the data situation concerning data deviations. The estimate remains a best-effort calculation, based on assumptions and limited data sources and tries to depict reality as best as is possible, given the available data.

For the estimation of the demand side of the cannabis market this paper relies and builds on the seminal work by Zobel et al. (2020). The team at Addiction Suisse, the "Ecole des sciences criminelles" and Unisanté are not only responsible for major research results on the situation of cannabis in Switzerland (e.g. concerning epidemiological data and waste-water analysis) in the last decades, but have also combined the most crucial data and information on the current situation of cannabis for the Canton of Vaud in order to estimate volumes and values of the market as well as to shed light on the organisation and structure of the cannabis supply chain. For the Swiss context, this project is of particular importance, as there previously had been very little research into the economic side of cannabis. The team of Addiction Suisse/Ecole des sciences criminelles/Unisanté has graciously shared their findings with me during the research process and has continually helped to shape this paper by being available for further questions and discussions. For this I wish to thank them and acknowledge their support explicitly.

One of the key reasons Zobel et al. had for the decision to focus on the canton Vaud, lies in the aforementioned availability of data and information on the cannabis market in Switzerland. Since the market is more complex, than other illegal substances (both in product heterogeneity, supply chains and market structure) not only demand, but also the supply of cannabis can differ between the various regions of Switzerland. Focusing on smaller areas or a single canton thus yields more accurate estimates, as more and better data is available on the cantonal level (for example concerning the waste-water analysis, the analysis of legal rulings or the information on the consumption of people not covered by population surveys). Vice versa, once the area under investigation becomes larger, accuracy usually goes down, as less information is available, and more assumptions must be made. For the purpose of this project, it is essential to focus on Switzerland as a country because only a national estimate allows for the subsequent analysis of potential (national) regulatory effects. Therefore, I have taken the approach developed by Addiction Suisse/Ecole des sciences criminelles/Unisanté and expanded upon it by drawing on additional data sources, focusing on the national level and disintegrating the results into the economic components to allow for further analysis. It is important to acknowledge, that this estimation is overall probably less accurate. However, given the data availability, it is still feasible and provides a basis for future, more detailed research into this fast-moving topic.

3.5 On cannabis data in Switzerland

This section summarizes the state of research on various aspects of cannabis in Switzerland, information that will serve as a basis for the calculations in this project. Sucht Schweiz together with the Institut für Begleit- und Sozialforschung provide regular data on substance use and abuse in Switzerland. Between 2011 and 2016 they conducted a "continuous rolling survey of addictive behaviours and related risks" (CoRolAR) with the most recent data available for 2016. Cannabis usage is one of the topics in this project and recent surveys have shown that about 34% (p. 83) of the Swiss population over 14 years of age have used Cannabis at least once in their life (life-time-prevalence). Recent usage (within the last 30 days) is reported by about 3.1% (p. 84) for 2016, up from 2.6% in 2011. A little more than half of these persons (56.9%) report usage of more than 3 days within the last 30 (Gmel et al., 2017).

Using the definitions of the Cannabis Use Disorder Identification Test (CUDIT) Marmet & Gmel (2017) analysed the share of problematic cannabis users and found that about 1.1% of the Swiss population have a problematic usage pattern of cannabis (8 points or more on the CUDIT). The share increases to around 75% for people with very frequent cannabis consumption (more than 4 times a week). They also find that the earlier the age-of-onset is, the higher is the likelihood for problematic consumption, which is in line with research from other countries. Van Ours & Williams (2007) for example analysed the dynamics of cannabis use in young Australians in light of a growing body of research which connects early adoption of cannabis use with increased risks to educational achievement, labour market participation and productivity, as well as longer, more regular and more intense use of cannabis. Using a combination of duration models and a split population hazard model, they analyse both the decision to start using cannabis as well as the decision to quit using it. Based on market price data and data from the Australian National Drug Strategy's Household Survey they conclude that for 12-22-year-olds in Australia in 1998 the risk of being a potential and actual cannabis user increases with a low educational background. They also find a price elasticity for the decision to start cannabis in the range of -0.50 to -0.70 as well as an increased risk to become a permanent user (pp. 589-590). Early adopters also are less likely to quit than the average cannabis adopter. Furthermore, their results suggest, that the decision to stop cannabis usage is not significantly affected by the price. Research into the dynamics of cannabis usage in young years is of high relevance to this project because cannabis is most prevalent among young people, as well as because these dynamics provide a basis for the understanding of a number of regulatory variables (such as marketing regulation, age limits, price controls, etc.) that affect consumption in the medium to long run (Vogel et al., 2019).

The cohort study Cannabismonitoring, which started in 2003, additionally provides data on consumption[15] of cannabis in Switzerland as well as some information on the structure of the cannabis market in Switzerland (Annaheim et al., 2012).

Information on the value chain of the Swiss cannabis market has different sources. There are for example works such as Pignolo (2017) who, with a sociological background, have conducted field-research with specific actors within the value chain of cannabis (dealers in this case). Similar but more generic work in France has been conducted by Ben Lakdhdar (2017) who used an empirical model to estimate dealers gains on various steps in the supply chain for France. They separately estimated profits of three different stages of trade: wholesale (700 – 1,500 persons in France, €250,000 - €500,000 annual profits), large-scale retail (6,000 – 13,000 persons in France, €35,000 - €77,000 annual profits) and small-scale retail (58,000 – 127,000 persons in France, €4,500 - €10,000 annual profits).

[15] There are several studies that have dealt with cannabis consumption in Switzerland of teenagers and young adults using different questions, different samples and different methodology. The Cannabismonitoring was an attempt to provide a coherent framework to the topic by conducting a longitudinal analysis in waves with a comparable questionnaire.

Müller (2004) has conducted work on the institutional retail sale of cannabis (such as cannabis shops which operated in Switzerland for a brief period, or clandestine cannabis retail outlets attached to shops selling other products). Further information on the supply sources of retail cannabis comes from Annaheim & Gmel (2009) who analysed data from the Cannabismonitoring 2004 and 2007 and found that about half of all 13–29-year-olds who consumed cannabis within the last 6 month got it from friends for free. Only about 6% bought it in a store, 13% bought it from a dealer, 34% bought it from friends and 9% held their own plants. This data is of great relevance to the understanding of the market structure for retail cannabis, as it shows, that the influence of "professional" distributors was limited at the time when considering the final step in the supply chain. The largest share of supply actually comes from within the immediate friend networks of consumers. Information on the Swiss cannabis market regarding prices, quality, accessibility and association with other drugs comes from Killias et al. (2011). They compared data (prices, quality, etc.) from 2004 with a fake-client study in 2009 to evaluate the effects of policy changes on the Swiss cannabis market and find that a more liberal policy approach pre-2004 correlated with an increase in use, while a more rigid form of prohibition post-2004 correlated with decreasing rates of use (p. 183). However, since other external factors overlapped with the changes in policy it is impossible to make a causal connection between policy changes and market changes, even though the data shows correlation. Additional data on the market structure in Switzerland is summarised by Baumann (2008). Based on estimations of cigarette paper revenue he calculates a demand of about 1b CHF in cannabis products (p. 13). For the cannabis stores that bloomed in Switzerland for a few years he calculated weekly revenue between 2.5m – 5m CHF and a generated tax income of about 10m-20m CHF annually (only counting VAT, p. 19–20).

Based on the available data and research, I use a four-step approach for the estimation of the cannabis system. To estimate the total volume of the cannabis market, first the total number of people who consume cannabis in Switzerland is estimated based on available population survey data, surveys on illegal drug use and additional data on less "integrated" people in Switzerland most likely not captured in population surveys. In the second step data on police and border patrol seizures is added which constitute a share of the market that is not consumed, but still produced/imported and potentially sold at wholesale or retail prices. In the third step I monetarize the total quantity consumed/seized in the market, by adding data on supply chains and production. The last step is breaking down the total value of the cannabis market into its economic components (gross output, imports, value added, intermediate inputs) to differentiate between legal and illegal activities as well as to be able to look at the industries affected.

3.6 Methodology: Volume of the Swiss Cannabis Market

Following the methodology set forth by Zobel et al. (2020, pp. 48–68), the project distinguishes three different elements that constitute the total amount of cannabis that is "consumed" annually in Switzerland. These three elements are:

- the quantity of cannabis consumed by cannabis consumers captured by population-wide surveys,
- cannabis consumed by consumers who are most likely not reached by population-wide surveys
- as well as the quantity of cannabis that is seized by police and border forces and does not actually reach a consumer.

Theoretically there would be a fourth segment, when thinking about the cannabis market not from a consumption but from a production perspective. There could be a quantity of cannabis that is produced and exported out of Switzerland to other countries. This would neither be consumed, nor fully seized by police forces but still represents a production value in Switzerland. However, qualitative data from our interviews with police forces, cannabis producers and industry experts indicate, that at the time of this analysis this is a phenomenon of negligible importance, even though this has been different in the past.[16] Around the turn of the millennium, it was not an uncommon occurrence to see Swiss cannabis in Dutch coffeeshops indicating frequent and wholesale export (ibid.).

The most common form of demand-side estimations of illegal drug use is using epidemiological prevalence data obtained from surveys (European Monitoring Centre for Drugs and Drug Addiction, 2012a, pp. 41–42; Haucap et al., 2018, p. 21; Hibell et al., 2012, pp. 31–60; Kilmer, Everingham, et al., 2014, p. 8; Zobel et al., 2020, pp. 48–68). The general concept is using data on drug use prevalence, frequency and average amounts consumed per consumption period to estimate annual or monthly amounts consumed. However, depending on the population under investigation and the data used for such estimations, there are methodological limitations to this approach (Dahlberg & Anderberg, 2013; Johnson, 2014; Kilbey & Asghar, 1992; Zobel et al., 2020, pp. 66–69). The most pressing being the problem of underreporting (through self-selection or by not answering truthfully) and representativeness (not being able to representatively capture the population under investigation). Additional problems can arise from specific issues in survey and question design (Zobel et al., 2020, pp. 55–69). A specific issue in relation to the consumption survey data used in this estimation lies in the lack of controlling for shared consumption (Zobel et al., 2020, pp. 61–65). Cannabis is commonly called a "social" drug, since it is often consumed in social settings within groups of friends or acquaintances. When asking

[16] Sven Schendekehl, personal communication (4 June 2021); During the project I contacted both cannabis community pundits, as well as people with extensive knowledge of cannabis production. The association "Legalize it!" has been active in Switzerland since 1990 as both a political proponent for regulatory change as well a guide for legal counselling with regard to cannabis-related issues. Sven Schendekehl, member of the board of "Legalize it!" was available for multiple interviews and has provided additional contacts in the cannabis community.

individual persons in any population about their *individual* consumption in joints or grams it is crucial to control for shared consumption. Otherwise, shared consumption can lead to an overestimation of consumed volumes by a factor of 2 in the best case (2 people sharing) or even more.

While the European Web Survey on Drugs tried to control for this problem by asking about consumption amounts, modes (pipe, joint, etc.) and whether the most recent consumption episode was shared with other people, the resulting data still indicates, that the individual consumption is probably distorted. This is because the line of questioning used in this survey would only yield correct information on *individual* consumption if the respondents would account for the degree of sharing when entering the amounts consumed (e.g., 1 joint equally shared by 2 people would mean 0.5 joints consumed individually).

Zobel et al. (2020, pp. 62–63) analysed individual consumption, sharing and purchasing data and concluded that there are indications that the controlling method used in this survey probably does not adequately correct for sharing and thus the individual consumption data is probably overestimated. Since there is no quantitative indication on how to correct for this issue and considering that the other demand-side estimation yields significantly higher volumes I decided to accept the limitations of this caveat. Another reason for doing so, is that the other source of uncertainty (underreporting) is distorting the result in the other direction (underestimation) and has, quantitatively speaking, likely a more severe impact on the distortion of the results.

Some of these methodological issues are addressed in the estimation by using adjusting factors for underreporting and using additional alternate data sources from waste-water-analysis to try to triangulate a more accurate value for the total quantity consumed.

3.6.1 CANNABIS CONSUMED BY CONSUMERS CAPTURED BY POPULATION-WIDE SURVEYS

For the estimation of cannabis consumption by the share of the Swiss population covered in population-wide surveys both equation 1 and 2 respectively are estimated for the quantity of marijuana (V_{MS}) and resin (V_{RS}), the two most common forms of cannabis in Switzerland.

Marijuana (or Marihuana), the most common form of cannabis in Switzerland, is used as an umbrella term describing the products consisting of dried buds, leaves and stems of the cannabis plant. Resin is the second most common form of cannabis product on the market and consists, as the name suggests, of dried and pressed cannabis plant resin derived mostly from trichomes which are most concentrated on and around the buds of the female cannabis plant. It is also commonly called Hashish. There are several other products that can be extracted from the cannabis plant (see Figure 21, page 181) using various methods. However, as of the time of writing, these products play a minor role on the illicit market for recreational cannabis in Switzerland.

P representing the number of people living in Switzerland for the reference year (2017) used for the estimation, S_i being the share of consumption group i, D_i represents the average number of annual consumption days for group i andA_i is the average amount consumed per consumption day for group i.

$$V_{MS} = \sum_{i=0}^{N} P \times S_{Mi} \times D_{Mi} \times A_{Mi} \qquad \textit{Eq. 1a}$$

$$V_{RS} = \sum_{i=0}^{N} P \times S_{Ri} \times D_{Ri} \times A_{Ri} \qquad \textit{Eq. 2a}$$

For P I use data from the federal statistical office (FSO) on the resident population of Switzerland for 2017 (8,419,550). The estimation for S_i are taken from Gmel et al. (2017, p. 84) for both 12-month and 30-day prevalence of cannabis consumption. While the data is from the survey conducted in 2016, it is the most recent data available at the time of analysis. It is important to note, that the monitoring of addiction ("Suchtmonitoring") does not differentiate between cannabis products for prevalence data, which is why additional data from the Switzerland-specific respondents of the European Web Survey on Drugs is used, that was conducted in 2016, as a proxy for breaking down S_i into S_{Mi} and S_{Ri} (Zobel et al., 2020, p. 51).

Table 1: Population prevalence of cannabis consumption in Switzerland 2016/2017[17]

Prevalence group	Population prevalence		
	Total	**of which use Marijuana**	**of which use Resin**
Last 30 days and ≥20 consumption days	0.793%	98.3%	63.6%
Last 30 days and ≥10 & ≤19 consumption days	0.322%	97.1%*	51.9%*
Last 30 days and ≥4 & ≤9 consumption days	0.650%	97.1%*	51.9%*
Last 30 days and ≥1 & ≤3 consumption days	1.335%	93.2%	25.0%
Last 12 month but not last 30 days	4.200%	93.7%	31.4%
Sum	*7.3%*		

[17] Gmel et al., (2017 p. 84,88); Zobel et al. (2020, p. 51).

	Nr. of people per group		
	Total	**of which use Marijuana**	**of which use Resin**
Last 30 days and ≥20 consumption days	57,445 (10.9%)	56,468	36,535
Last 30 days and ≥10 & ≤19 consumption days	23,304 (4.4%)	22,628	12,095
Last 30 days and ≥4 & ≤9 consumption days	47,113 (8.9%)	45,746	24,451
Last 30 days and ≥1 & ≤3 consumption days	96,752 (18.3%)	90,173	24,188
Last 12 month but not last 30 days	304,315 (57.5%)	285,143	95,555
Sum	***528,928***	***500,159***	***192,824***

**both groups were aggregated due to a very small sample size*

The results in Table 1 show, that the purported number of half a million Cannabis consumers, while true, is somewhat misleading in describing the extent of cannabis consumption in Switzerland, when taking into account, that more than half of those consumers (57.5%) report a sporadic usage pattern and have not used cannabis in the last 30 days. The number of very frequent users with more than 20 consumption days in the last 30 days amounts to just short of 60,000 people. However, with more than one third of the Swiss Population having tried cannabis consumption at least once in their live, considering cannabis consumption as "deviant" behaviour, as it was done for large stretches of the 20th century, (H. Becker, 1963) would refute this societal reality.

Including the average daily consumption amounts from the analysis of Zobel et al. (2020, p. 59), the pattern becomes even more accentuated. Not only do very frequent users consume significantly more often, but they also consume much more quantity per consumption day than users with a lower frequency.

Combining both factors yields the average and total annual consumption amounts per prevalence group and per product (Table 2).

Table 2: Average annual consumption amounts in g per prevalence group and per product[18]

Prevalence group	**Average annual consumption amounts in g**	
	Marijuana	**Resin**
Last 30 days and ≥20 consumption days	255.8	171.8
Last 30 days and ≥10 & ≤19 consumption days	59.3	24.2
Last 30 days and ≥4 & ≤9 consumption days	22.3	9.8
Last 30 days and ≥1 & ≤3 consumption days	5.3	5.2
Last 12 month but not last 30 days	16.6	25.5
Total annual consumption per group in kg		
	Marijuana	**Resin**
Last 30 days and ≥20 consumption days	14,447	6,275
Last 30 days and ≥10 & ≤19 consumption days	1,341	292
Last 30 days and ≥4 & ≤9 consumption days	1,019	240
Last 30 days and ≥1 & ≤3 consumption days	481	125
Last 12 month but not last 30 days	4,742	2,438
Sum	*22,030*	*9,370*

[18] Zobel et al. (2020, p. 60).

3.6.2 Cannabis consumed by consumers not captured by population-wide surveys

Zobel et al. (2020, pp. 25–26, 52–53) suggest, that in addition to the estimation in the previous chapter, there is another group of cannabis consumer that is most likely not or not adequately captured in the population surveys used as the basis for the previous estimation. These are people participating in low-threshold drug use facilities and people in substitution treatments. Some of the reasons, why these people are probably not covered in population surveys are current or previous homelessness, jail, no or little financial means and connected limited or no availability by telephone and/or little interest to participate in telephone surveys (truthfully) (Kilmer et al., 2013, pp. 8–9; Zobel et al., 2020, p. 68). While these factors do not apply to *all* people in low-threshold facilities or substitution, they are widespread enough, to justify the addition of this group in our estimation, especially, because the amounts consumed by this group are relatively high per person. Zobel et al. (2020) base their estimation of this subgroup on two different statistics. One the one hand on visitors of low-threshold facilities and on the other hand people covered in substitution treatment (both groups are not mutually exclusive). While the numbers for people in substitution treatment are available on a national level[19] in the national substitution statistic, the number of people in low-threshold facilities is not. This is because on the one hand these facilities are usually organized on a cantonal or even local level and on the other hand because there is no national aggregate for these facilities. In addition to the lack of the total amount of people in these facilities, the second and third variable needed for the estimation (share of people consuming cannabis and average amounts) are also not available nationally.

For these reasons I have decided to estimate the volume consumed by people not covered by population surveys in a less granular fashion. In order to extrapolate the data from the canton

[19] See substitution.ch.

Vaud to the national level, I have calculated the total share of the population of the canton Vaud that Zobel et al. (2020) have concluded are in either a low-threshold facility and/or substitution treatment and consume cannabis regularly and have applied this share to the national population of Switzerland (2017). Obviously, there are caveats to this method. The most obvious being, that the data for the canton of Vaud is not necessarily representative for the rest of Switzerland. This could be due to various factors: differences in consumption patterns, differences in the propensity to visit low-threshold facilities/substitution treatments, differences in cannabis usage of said groups or differences in the availability of low-threshold facilities/substitution treatment. Unfortunately, due to the lack of additional data on the subject it is not possible to control for these factors currently.

While I acknowledge, that this estimation should be improved, once more data becomes available, the resulting value of 6.868 consumers nationally does not appear to be completely off. One way of at least partially validating this result is by comparing the national substitution statistic data as well as the share of people in substitution treatment consuming cannabis (37.06%) that Zobel et al. (2020 p. 52) report. For the reference year of this estimation (2017) substitution.ch reports an average of 15.065 people in the national substitution statistic. Applying the share of cannabis consumers from Zobel et al. to this number yields about 5,574 (81% of our estimate of 6.868 people) cannabis consumers in substitution treatment. Since people, not present in the national substitution statistic but participating in low-threshold facilities are not included and need to be added to this estimate, the overall estimation does seem plausible.

For cannabis consumers not covered by population surveys I thus estimate:

$$V_{M\bar{S}} = C_M \times A_M \qquad \textit{Eq. 3}$$

$$V_{R\bar{S}} = C_R \times A_R \qquad \textit{Eq. 4}$$

C representing the estimated number of consumers not covered by population surveys (6.868) for the reference year (2017) used for the estimation, A being the average annual consumption amounts of marijuana and resin respectively, following the estimates in Zobel et al. (2020 p. 65).

3.6.3 CANNABIS SEIZED BY POLICE AND BORDER PATROL FORCES

To fully estimate the total amount of cannabis in the Swiss market, the quantity seized by police and border patrol forces needs to be added to the amount consumed by the market. While this volume is not being actively consumed by cannabis users, it is "consumed" by the police instead, in the sense that it is removed from the market and destroyed. The quantity seized thus represent cannabis that has been produced or imported and at least partially been traded on the wholesale or retail level. The total amount of annual seizures is available from the PKS 2017 (Federal Statistical Office, 2016b) by different products[20]. These numbers represent the aggregate of all seizures made by police forces in Switzerland regardless on which level they occur. For police seizures I estimate the following equations:

$$V_{MP} = V_{MF} \times d_F + V_{MD} + V_M \qquad \textit{Eq. 5}$$

V_{MF} represents the volume of fresh marijuana plants which are converted to market products using a weight loss factor (d_F) (Warner et al., 2017) of 67%. V_{MD} contains seized plants that are

[20] I have excluded cannabis seeds, saplings, synthetic cannabinoids and hashish oils because they only make up a very small share of seizures and based on the lack of market data I estimate that a valuation of said items in monetary terms is not feasible.

already dried and V_M is marijuana processed as consumable product. The estimation assumes both that the fresh plants have reached harvest weight as well as that the entire plant is used in one way or the other (e.g. to produce oil).[21] V_{MD} can be taken straight from the PKS and does not need to be constructed separately.

3.6.4 PRE-ADJUSTMENT RESULTS AND LITERATURE-BASED ADJUSTMENT FACTORS

Table 3 shows the pre-adjustment estimation results for all three elements of the quantity estimation for the Swiss cannabis market. Considering all three elements, a total of about 26.7t of marijuana and 10.9t of resin are estimated to be consumed or seized in Switzerland annually for the reference year (2017).

As mentioned in the preface of this chapter, there are a number of methodological considerations when estimating the consumption of illegal substances from survey data (Kilmer et al., 2013, pp. 6–15; Zobel et al., 2020, pp. 67–68).

The first of which, a possible underrepresentation of relevant subsets of the population, was already addressed by including an estimate of people in substitution treatment and using low-threshold facilities.

The second factor, which traditionally plagues survey-based research on illegal activity is underreporting. Underreporting occurs, when people who are asked, or self-report on a certain behaviour

[21] While the first assumption is probably true given the fact, that the statistic specifies fresh plants as "fresh plants containing buds" the latter assumption probably does not hold for all growing operations. The processing of stems and roots is significantly more labour and time intensive than the processing of buds. Since the resulting products do not have the same market relevance as marijuana has, it is likely, that some growing operations simply discard non-usable parts of the plant. Since fresh plants only make up about 3% of all seizures, the effect of a possible overestimation is negligible though.

(such as illegal drug usage) do not (self-selection), or do not truthfully answer the question (concealment). This issue is particularly relevant for topics, which are illegal, carry a social stigma or are particularly intimate (such as drug usage, violence, sexuality, tax evasion, etc.).

Table 3: Total annual cannabis consumption and police seizures in kg (pre-adjustment)

	Marijuana	**Resin**
Last 30 days and ≥20 consumption days	14,447	6,275
Last 30 days and ≥10 & ≤19 consumption days	1,341	292
Last 30 days and ≥4 & ≤9 consumption days	1,019	240
Last 30 days and ≥1 & ≤3 consumption days	481	125
Last 12 month but not last 30 days	4,742	2,438
Consumers not covered by pop.-surveys	2,240	953
Police seizures	2,416	543
Sum	***26,687***	***10,866***

Since cannabis is illegal in Switzerland, does carry a social stigma and can have severe legal consequences, it is very likely, that the "real" rate of cannabis consumption throughout the population is not adequately reflected in representative population surveys, such as the Continuous Rolling Survey of Addictive Behaviours and Risks (CoRolAR) used in this estimation. There have been many attempts by researchers to quantify the degree, to which underreporting for illegal drug use occurs. This is usually done by comparing self-reported levels of drug-use to biological samples of the same people, that are tested and compared to the self-reported data. One limitation of these approaches is usually, that because a secondary data source of biological samples is needed, these studies happen usually in the context of natural experiments. This means for example, that processes that per-se include the taking of biological samples (e.g. during army recruitment or in emergency rooms) can be expanded by a survey on the behaviour under investigation in order to compare samples to self-reported data. One limitation of these setting is, that they focus only on a particular group of people in a particular cultural context (e.g. students, recruits, emergency room visitors, etc.) (Chen et al., 2006; T. A. Gray & Wish, 1999; Johnson, 2014; Morral et al., 2000; Palamar et al., 2021). This is important, because the likelihood of underreporting does, amongst other factors, depend on the cultural context of the survey and the topic. Research shows, that underreporting is less of an issue, if the stigma or penalty of the topic under investigation is comparatively small. Even experiments dealing with the same topic (e.g. cannabis consumption) can yield very different results, depending of the population participating and the cultural context of the experiment. When transferring conclusions from these experimental results into other contexts, these issues need to be accounted for when interpreting results. Another limitation of this approach can be, that the participants in said process can be aware of the setting (survey and follow-up sample) and are thus less likely to conceal their true behaviour, if they know, they might be caught in a lie during testing.

While these experiments are no golden bullet to solve this methodological hurdle, they do give some insight into the potential dimension of underreporting, when conducted in comparable context to Switzerland. To stay in line with the methodology of Zobel et al. (2020, p. 69) I adjust the provisional survey-based estimates with a literature-based adjustment factor for underreporting of cannabis consumption (1.35). The reason for the selection of this adjustment factor at the upper end of the literature-based adjustment spectrum is twofold. On the one hand, the WBE of cannabis consumption quantity is significantly higher, than the survey-based estimate. Even allowing for methodological issues and uncertainty in the measurements and regional application, this indicates, that the "true" consumption quantity is likely higher, than even the adjusted survey-based estimate and thus in return potentially justifying a higher adjustment factor. The second reason is, that similar research with other, legal substances show, that the actual underreporting quantity in survey based estimates can, depending on the context, population and methodology, be even higher in the range of 38% (wine), 49% (beer) 65% (spirits) (Cook, 2007; Stockwell et al., 2014) suggesting significantly higher adjustment factors between that could even exceed 2.

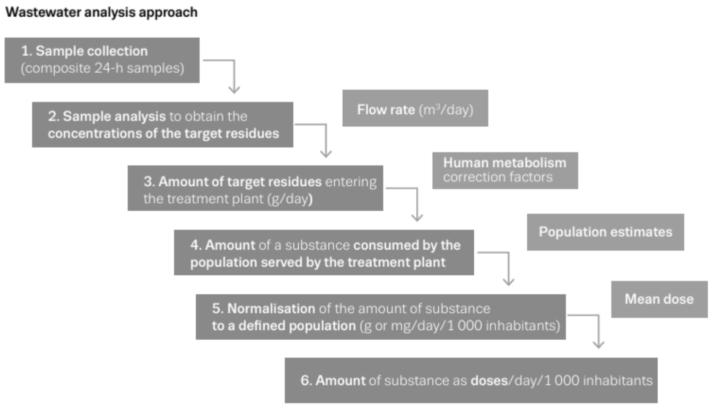
The selected adjustment factor (1.35) is applied only to the population survey-based estimation groups though, the volumes of consumers not covered by population surveys is probably not affected by underreporting to a significant degree, as there is no apparent incentive to conceal consumption, even though the share of cannabis consumers is also originally based on survey-data (Zobel et al., 2020, p. 69).

3.6.5 Wastewater-based epidemiology adjustment

Until recently, it would not have been possible, to further validate or triangulate this survey-based estimate of consumption volumes in the Swiss market. However, recent advances in forensic chemistry and wastewater-based epidemiology (WBE) have led to the development of a new approach combining epidemiological survey data estimates with the analysis of wastewater for specific geographic areas (Been et al., 2016; Causanilles et al., 2017; Daughton, 2001; European Monitoring Centre for Drugs and Drug Addiction, 2020c; Van Wel et al., 2015). The underlying concept of WBE to estimate substance use is shown in Figure 5.

Usually the comparison of survey-based epidemiological estimates with wastewater-based estimates requires an identical scope both in terms of the population, that is covered in both analysis as well as concerning the timeframe, that is under investigation. Unfortunately, for Switzerland there has not been a research project yet, that tried to compare both national, survey-based estimates with national waste-water analysis. Notwithstanding, Zobel et al. (2020 p. 71–85) have done exactly this on a regional level. They first estimated survey-based consumption volumes for the entire canton and then used WBE in multiple regions within the canton of Vaud to construct a cantonal volume based on WBE (Zobel et al. (2020 p. 80).

Figure 4: Conceptual approach to wastewater analysis for substances[22]



While there are limitations to both the experimental design as well as to the methodology used (Zobel et al. (2020 p. 75–77), this research approach provides a first estimate of the potential degree of underreporting in survey-based cannabis consumption for the context of the canton Vaud. Comparing the survey-based and literature adjusted estimate for the canton of Vaud (3.5 tons) to the WBE estimate (5.1 tons) yields a difference of about 46%. Zobel et al. formulated three non-exclusive hypotheses for this difference (Zobel et al. (2020 p. 86):

- The survey-based demand side estimation might be too low, even with the substantial literature-based adjustment factor of 1.43. This could be due to an underrepresentation of frequent users.

[22] Reproduced with kind permission of the European Monitoring Centre for Drugs and Drug Addiction (2020) based on Castiglioni et al. (2013).

- The WBE estimation could be too high (see the methodological discussion: Zobel et al. (2020 p. 75–77).
- There could be a significant difference in the consumption patterns between the regions of the wastewater plants covered in the analysis and the rest of the canton.

The analysis that Zobel et al. have conducted was focused on the canton of Vaud with good reason. Even on the cantonal level there are several open questions for future research that need to be addressed to further refine the analysis. Because the aim of this analysis is to provide a national estimate as an economic basis for the simulation of regulatory scenarios and since it is not possible to discern the validity of each of these hypotheses without additional data, I have thus decided to follow the decision of Zobel et al. and adjust the survey-based consumption estimate by half the difference between the survey-based and literature adjusted estimate and the WBE estimation with an adjustment factor of 1.23. This decision is based on two premises. The first being, that the difference in the two estimation methods is at least to some degree methodologically valid and indicates, that the actual amount consumed is higher, than the literature adjusted population-survey-based estimation. The second premise is that the underlying reasons for the difference between the two estimations on the cantonal level in Vaud are applicable to Switzerland overall. I believe this premise has merit, since there is ample evidence for the first hypothesis with the question mainly being on the degree of underreporting and not its existence itself. At the same time, I found no evidence or indication for the second or third hypothesis. However, if future research provides additional insight on hypothesis two or three, the presumptions leading to this decision might have to be revisited.

Coming back to the original equations (*Eq. 1a*, *Eq. 2a*) for the population-survey based segments, they are augmented with both the literature-based and WBE-based adjustment factors (C_l *and* C_{WBE}) to represent the effective equations used for the estimation (*Eq. 1b, Eq. 2b*). Since the adjustment based on the WBE analysis is based on the difference in estimated overall amount of cannabis consumption and the precise methodological reason for the divergence remains unclear for now it is applied to both, the consumers covered by population-based surveys and those who are not.

$$V_{MS} = \sum_{i=0}^{N} P \times S_{Mi} \times D_{Mi} \times A_{Mi} \times C_l \times C_{WBE} \qquad \textit{Eq. 1b}$$

$$V_{RS} = \sum_{i=0}^{N} P \times S_{Ri} \times D_{Ri} \times A_{Ri} \times C_l \times C_{WBE} \qquad \textit{Eq. 2b}$$

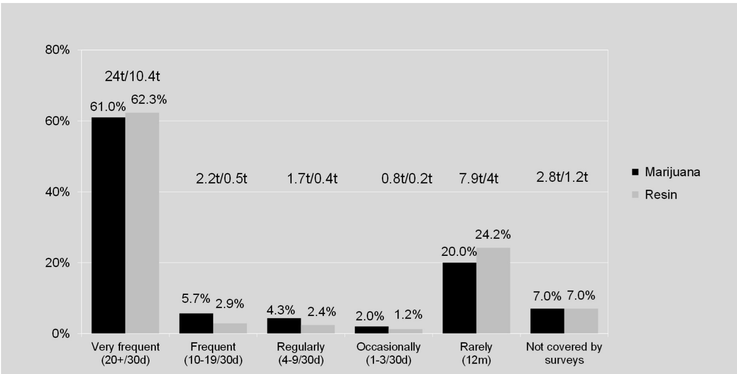
Table 4 shows the sum of final demand consisting of both consumers and police seizures and including both adjustment factors. Overall, the estimate yields about 41.7t of marijuana and 17.3t of resin.

Table 4: Literature and WBE adjusted total annual cannabis consumption and police seizures in kg

	Marijuana	**Resin**
Last 30 days and ≥20 consumption days	23,961	10,408
Last 30 days and ≥10 & ≤19 consumption days	2,224	485
Last 30 days and ≥4 & ≤9 consumption days	1,690	397
Last 30 days and ≥1 & ≤3 consumption days	797	207
Last 12 month but not last 30 days	7,865	4,043
Consumers not covered by pop.-surveys	2,753	1171
Police seizures	2,416	543
Sum	***41,707***	***17,254***

Figure 6 graphically dissects the consumption quantities into different consumer types. Very frequent consumers of cannabis who consume almost on a daily basis make up the largest share by a significant margin. Over 60% of the consumed amount is taken in by this group with user who report consumption in the last 12 months but not in the last 30 days making up the second largest group with about 20%. The sharp contrast between very frequent consumers and the other group is influenced in particular by the significantly larger annual consumption of this group. With about 255g of annual consumption this group consumes more than 4 times the amount of the second most frequent group (59g, see Table 2). What these results clearly show, is that the effects of any form of regulatory change will significantly depend on the reaction of the group of very frequent consumers as they are responsible for more than 60% of all cannabis consumed in Switzerland.

Figure 5: Estimated consumption share and quantity per prevalence group



3.7 METHODOLOGY: VALUE OF THE SWISS CANNABIS MARKET

While the volume of final demand estimated in the previous chapter provides some first insight, into the size of the cannabis market in Switzerland, for an economic analysis it is necessary to go one step further and dissect the quantity into its economic components in three steps.

In the first step the police seizures are broken into two different parts, the first being products and volume traded on the farm-gate/wholesale level, the other being volume that is being traded at retail value. The second step is breaking down the supply chain of the cannabis consumed in the Swiss market into home-grown, imported and domestically, commercially produced. The third step is breaking down the supply chain of each segment into their respective economic components (productions and trade costs (intermediary inputs), value added (capital consumption, wages, profits) as well as import value.

3.7.1 PRODUCTION-, WHOLESALE-, AND RETAIL PRICES

The first step in the economic estimate for the Swiss cannabis market was to estimate the consumed and seized value (final demand). The second step, the estimation of the economic value of these volumes, requires valuating these volumes at the corresponding prices of the supply chain, when they are taken out of circulation by final demand. Doing so requires three steps:

- to dissect the final demand volume into the respective shares taken out of circulation at three different stages: production, wholesale and retail (see subsequent chapters),
- to estimate and apply prices/costs for the volumes for each of these stages,
- and to estimate the share of domestic production and imports.

Production prices for cannabis are influenced by many factors: the form of production (indoor, greenhouse, outdoor), the degree of protection/concealment required, the expertise and know-how of the producers as well as the prices for intermediary inputs and labour to name a few. While there is a fair share of research on cannabis production and production costs, most of it stems from countries other than Switzerland. In order to come up with an estimate for domestic production cost I have tried to triangulate an estimate by combining three data sources:

- Available research on domestic cannabis production
- Available research on cannabis production internationally
- Expert Interviews with narcotic departments at cantonal police forces (see chapter 3.3 and annex), industry experts from the CBD industry22F23 and community representatives from the IG-Hanf

One significant influence on the production price of cannabis is the form, in which it is grown. There are three broad types of how this is done in Switzerland:

- Outdoor plantations
- Small scale indoor plantations (grow-tents)
- Indoor production in greenhouses or greenhouse style warehouses

While growing cannabis outdoors could theoretically[24] benefit from the same mechanical and procedural support as e.g. tomatoes or asparagus (Caulkins, 2010, p. 8) as for instance pre-seeding in greenhouses, mechanized transplant into fields, large-scale fertilizer application, automated hydration and mechanized

[23] Since CBD-Cannabis with less than 1% of THC is legal in Switzerland, there is a growing industry of professional CBD-cannabis producers. Since the difference between the legal and illegal form of cannabis is only chemical, production processes and costs between the two products are almost identical. Pure Holding is the Swiss market leader for CBD cannabis products and provided valuable expert input into the production process. I conducted telephone interviews with both the chief operating officer as well as the chief executive officer to cover the technical details of the production process as well as economic and regulatory questions of cannabis.

[24] To produce CBD Cannabis in Switzerland, this form of production process is actually used, even though rather rarely and on a comparably small scale.

harvesting and processing, according to cantonal police forces, this is – for THC cannabis – not happening in Switzerland on a notable scale for two reasons. Firstly, there are significant advantages of indoor production over outdoor production: multiple harvests all year around virtually unaffected by weather/seasons, controlling environmental factors (e.g. humidity, temperature, pest-control) as well as much easier concealment and security (concerning law-enforcement but also competitive producers, consumers or other criminal elements such as rocker or motorcycle gangs). Secondly, even disregarding the advantages of indoor production, scaling outdoor production to a degree that would benefit from these features is not a very good idea from a risk management perspective. This is in line with what cantonal police forces report. The most common strategy they encounter is spreading production over multiple medium-sized operations, rather than focusing and scaling very large operations. This way, if one operation is seized, there is continuity in production and revenue. Since outdoor growing operations, just like indoor operations require concealment, security, and constant attention. All these features are a lot easier to provide if the operation is relatively small.

The second group of operations are small scale indoor plantations, usually in a single room or basement. While these operations are often fairly small by themselves (1-20 plants (Zobel et al., 2020, p. 96, interviews with cantonal police forces), the potentially high prevalence of these operations could be a reason for these operations to make up a significant share of overall production. Zobel et al. (2020, pp. 10, 96) for example estimate that this form of production could contribute 400-550 kg (about 10%) annually to the supply in the canton of Vaud. Technically, this kind of operation very often uses sophisticated growing equipment (e.g. growboxes/grow-tents with automated lighting, humidity and temperature controls, etc.) which allows semi-professional results and good crop yield with comparably little effort both in terms of labour input and investment costs upfront. Additionally, the detection risk for these operations is very small with the most common causes for detection being reports to the police or accidental detection. Less sophisticated setups, only using artificial lighting or growing on rooftops or balconies are also common in this group.

The third and most relevant, in terms of volume, are medium to large indoor growing operations in greenhouses or greenhouse style warehouses. These operations can range from a few hundred plants up to 10,000 plants in extraordinary cases (Zobel et al., 2020, p. 96, interviews with cantonal police forces) and are often housed in old industrial complexes, warehouses, or large agricultural buildings. Since these operations require significant upfront investments, they are often run by small individual groups or a network of producers that can provide the financial background and know-how. As a rule of thumb, police forces estimate that the investment for the setup of a growing operation is usually amortized by the sale of the first harvest. Since professional growing operations can produce 3-6 harvests a year, the setup of a growing operation can yield sustained profits very quickly. The interviews with police representatives revealed, that medium to large operations are probably the largest source of domestically grown marijuana in terms of quantity, which is also what Zobel et al. estimate.

3.7.2 Domestic production prices

The average production price for domestically produced marijuana is estimated at 1.75 CHF/g or 1,750 CHF/kg. This price includes only production costs (e.g. raw materials, energy, rent, equipment, packaging etc.) and takes into account the previously outlined structure of different production forms and sizes. Labour costs are not counted as part of the production costs, as there are no "formal" labour costs due to the illegality of the tasks involved. Instead, the labour costs are part of the value-added (with profits and depreciation). This is because the people working in cannabis production generally are not formally employed and do not pay taxes or social security or benefits. The interviews with cantonal police forces indicate, that there are two broad forms of labour organisation which are often encountered. The first are small cooperatives that usually consist of a group of people sharing costs and labour. For these cooperatives, reimbursement often happens through profit sharing agreements, as the people financing, operating and profiting from the production are the same.

The second form is slightly more vertical and consists of a head organisation that provides financing and/or infrastructure and is operating multiple production sites with individual teams working each site. The latter form can be more similar to a traditional employer/employee relationship, as the teams working each site are sometimes reimbursed with fixed "wages" rather than through profit sharing agreements.

The average estimated domestic production price is based on three sources. The first is information derived from interviews with delinquents during police operations and investigations[25]. The second is reference data from CBD cannabis production sites (which is legal in Switzerland). This information comes from interviews conducted with narcotic experts at cantonal police forces in Switzerland (see chapter 3.3) and are based on investigation and interrogations. The CBD data was additionally verified with expert input by the IG Hanf, which is the industry association for hemp in Switzerland, as well as CBD cannabis producers in Switzerland. Last but not least, I also spoke to two Grow shop operators, one in the Zurich area and one in the St. Gallen area. The police experts gave us different estimates on the anecdotal information they had. One mentioned production price for illegal cannabis of 500-2,000 CHF/kg depending on the degree of professionalisation, another mentioned 1,000-1,800 CHF/kg with 1,000 CHF being a very professional operation. A third said production prices are within 2,000-6,000 CHF/kg (but including labour costs) and a fourth referenced CBD production costs of about 1,000 CHF/kg for professional operations.

[25] Which I received by proxy through our interviews with police representatives.

The third source are literature based production estimations from other jurisdictions for legal production costs (Caulkins, 2010, p. 10). The latter have been converted using currency exchange rates and price level differences to account for differences between the US and Switzerland. However, for both data sources it needs to be noted, that some of these production estimates are based on either a factually legal production (CBD) or a presumed legal production. This is relevant, because according to the police interviews, I conducted there are additional costs to producing illegally. Video surveillance, 24h security as well as the risk of detection and seizure to name a few. This mark-up needs to be accounted for when comparing estimates.

In addition to previous research on the topic[26] Miron (2003) empirically investigates most steps along the value chain of drug markets such as transportation, storage, retailing costs, etc. rather than simply comparing production costs abroad to retail prices in the U.S. for drugs and non-illegal agricultural products. Depending on which benchmark is used, he claims, the prohibition mark-up factor on prices can vary from 2 to several hundred depending on the product and the market.

A different point of reference is the production of medical cannabis. In the Netherlands, medical cannabis is available on prescriptions and is produced by Bedrocan BV.

> "Bedrocan reports that its marginal cost for a producing a kilogram of high-potency, medical grade, organic cannabis that has been professionally tested, packaged, and gamma irradiated is approximately €1,000. When thinking about how this figure could be used to inform estimates of the cost of producing legal cannabis for the non-medical market, one should keep in mind that 1) This is a heavily-regulated, high-quality product intended to be used as medicine by those who are sick; 2) the cannabis is produced in a relatively small indoor facility in a country

[26] See for example Friedman (1989) and (Bennett, 1992) for a classical exchange of arguments on the debate.

with a high cost of living; and 3) there is no competition." (Kilmer & Burgdorf, 2013, p. 35)

While these costs are not quite comparable to our estimate, as they include labour costs, they are for a different product (higher quality standards) and are taken from a different country with a different price level than Switzerland, they do give a reference point for a potential development of production prices in a licit market. Similar estimates are available for the production of medicinal cannabis in Australia by the department of health (Deloitte Access Economics, 2016). They estimate the production costs for medicinal cannabis between 782 – 1,670 CHF[27] depending on the production form (broadacre, greenhouse, indoor). This estimate includes production, labour, security and compliance costs for the Australian market.

3.7.3 Domestic wholesale prices

Wholesale prices are the second source of estimated prices. Wholesale prices in this estimate have a different role than production prices, as their primary purpose in this estimation is not to valuate a certain share of the market, but rather to dissect the total retail value into different economic components. They are thus added at a later stage of estimation when decomposing the retail value into its components.

Zobel et al., (2020, pp. 101–102) as well as the police experts I interviewed describe the supply chain of cannabis as relatively "short". By this I mean, that there are only 2-4 actors from the original producer to the final consumers. For smaller and medium sized domestic productions that operate both in a geographical and socially limited context, it is not uncommon to maximize profits by selling straight from the producer to the consumer (two-actor supply chain). This way, the producer reaps in the full benefit

[27] Converted using average exchange rates and price levels from (OECD, 2020; x-rates.com, 2020).

and can completely internalise the trade margin between production costs and retail costs.

For larger domestic producers however, it is sometimes not appealing to sell directly to the final customer. One reason for this is the complexity of the process. Regularly selling hundreds or thousands of kilos of cannabis directly to final customers would require both a very large customer base as well as sophisticated and somewhat centralized transport, storage and sales processes that would require many people in a single organisation (Tzvetkova et al., 2016). While this form of vertical integration is common and can have advantages in legal production circumstances, it becomes very risky in illegal circumstances. For the same risk-management reasons that producers use various medium to large production facilities to minimise risk of detection and allow for business continuity, large scaler producers often prefer to work through large wholesale traders. This minimizes the people aware of the production and by extension the risk of detection. In this form of organisation, it is often irrelevant to the producer, if small-scale dealers are captured by the police, because they are not aware of the details of the production operation. Since the (semi)professional forms of medium to large production operations provide a significant share of the domestically produced cannabis in Switzerland, it can be reasonably assumed, that intermediary wholesale traders are a common occurrence in many supply chains. This is in line with both Zobel et al. (2020, p. 102) as well as with information provided by the police experts I interviewed. Another indicator that supports this hypothesis is the fact that the police statistic shows about 4 times as many charges for less severe cases of trade than for production and double the charges for severe cases of trade in comparison to production (Federal Statistical Office, 2018). Albeit it needs to be added that there could be other reasons that also influence this difference (e.g. ease of detection, police strategy, etc.).

3.7.4 Import share and prices for marijuana and resin

While the previous chapters outlined the domestic production, a significant share of the market for marijuana and resin is provided not by domestic production, but by imports from abroad. Unfortunately, there is almost no information available on the distribution between domestically produced cannabis and products imported from abroad. The interviews I conducted with police officials who have been investigating the cannabis economy suggest, that the import share for marijuana lies somewhere between 30-70% with a focus on 30-50%.[28] Due to the lack of additional data to corroborate this estimate I use a conservative estimate of 33% as the import share for marijuana in this estimation. If the real value were higher, the domestic effects would be correspondingly lower. The import share appears to be higher in cantons with international borders (e.g. Ticino, Basel, Valais) and smaller in cantons where this is not the case (e.g. Lucerne). Imports are often organized by groups with strong (cultural) ties to the export regions (e.g. Spain, Italy, Balkans) who can provide both the connections to production organisations as well as the logistic required to smuggle the products into Switzerland. Another development which was mentioned often, is that the domestic production has gained more prominence over the last two decades and has increased both in the degree of professionalization as well as production capacity.

For cannabis resin, the situation is different. On the one hand, the demand for resin is significantly smaller than for marijuana (see Table 4). On the other hand, the demand seems to have increased slightly lately (Zobel et al. (2020, p. 111). Zobel et al. mention that the quality of resin increased and that it is less likely for the purchasers to be conned with spiked products (e.g. diluted marijuana with CBD components). This is in line with developments

[28] The information provided primarily stems from seizures, interviews and interrogations conducted by the police.

that were mentioned during our expert interviews with cantonal narcotic experts. Apparently significant investments into the capacity of CBD cannabis production have led to a price decrease in the CBD market to the point, where the wholesale price is not exceeding cost prices for some producers, especially if they have a high-cost structure or production risks. It was mentioned during the interviews that as a reaction to this situation, in individual cases CBD cannabis has been spiked with synthetic cannabinoids and subsequently was sold as "fake" THC marijuana. It was also mentioned that CBD cannabis is sometimes used to dilute THC marijuana by artificially inflating quantities with CBD cannabis.

The demand for resin, according to the police interviews, seems to be covered almost completely by imports. Every cantonal narcotic expert I spoke to unisono said that the resin volume handled in the market is almost completely imported from abroad. Research on the topic and other experts I talked to confirm this situation(European Monitoring Centre for Drugs and Drug Addiction, 2012b; European Monitoring Centre for Drugs and Drug Addiction & Europol, 2019; Gamella & Jimenez Rodrigo, 2008; M. Mosimann, personal communication, 31 May 2021; Sven Schendekehl, personal communication, 4 June 2021). There is also some anecdotal evidence for this situation because during the Covid-19 lockdown in Switzerland (2020-2021), when most European borders were closed temporarily, the resin market largely dried up for a few months (Pignolo, 2020) and it was very hard to source resin in some parts of Switzerland (Sven Schendekehl, personal communication, 4 June 2021). This was not the case for marijuana. There is almost surely a small fraction of resin production in Switzerland domestically[29], but it appears to be a niche market of negligible importance with respect to quantity. For this reason, I use the simplified assumption that all the resin consumed and seized in Switzerland is imported from abroad.

[29] One indicator for this is the small share of resin consumers who indicate that they produce it themselves (Zobel et al. (2020, p. 64).

The data situation on import prices is similar to wholesale prices. Except for anecdotal information from interrogations, court proceedings and expert insights from the police, there is little information on the price for imported marijuana and resin into Switzerland. Nonetheless, Switzerland is not an isolated country and the products and supply chains that provide illegal cannabis to Switzerland are at least partially similar to other surrounding countries. There is a fairly well-established network of major production centres and trade routes for cannabis in Europe. The five most mentioned regions outside of Europe are:

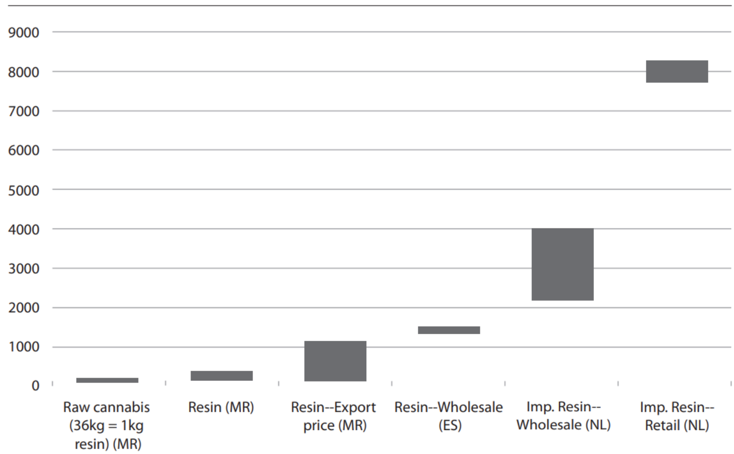
- The Balkan region (including Albania, Kosovo, Serbia, etc.)
- North-Africa (Morocco (particularly for resin)
- The middle east (Lebanon, Turkey, Egypt, etc.),
- South-west Asia (Afghanistan, Pakistan, Nepal, India, etc.)
- Sub-Saharan Africa (South Africa, Senegal, Mozambique)
  (European Monitoring Centre for Drugs and Drug Addiction, 2012b, p. 49).

But there are also major production centres within Europe that export to other countries. The EMCDDA mentions the Netherlands, Belgium, but also the Iberian Peninsula (European Monitoring Centre for Drugs and Drug Addiction, 2012b, p. 72). Both the Netherlands as well as the Iberian Peninsula serve in a double function in the European cannabis trade as they act as both a producer, as well as a distribution hub for cannabis from outside of Europe.

Often, available estimates for import prices of cannabis products have a very large bandwidth, rendering them unfeasible for the purpose of this estimation. The reason, why it is so hard to put a precise number on import prices for marijuana and resin is shown in Figure 7 in an exemplary fashion. The figure shows, how the price of a kilo of retail grade cannabis resin develops from the raw material harvest in Morocco all the way to the retail value in the Netherlands, which is a common route for cannabis products (European Monitoring Centre for Drugs and Drug Addiction, 2012b). It includes product processing and export in Morocco, wholesale import in Spain, wholesale import to the Netherlands and finally the actual retail value when sold to customers in the Netherlands.

For this estimation, the goals is to estimate import prices in Switzerland. Transfering the concept of Figure 7, the corresponding value would be the second value from the right. It is the price paid by wholesale dealers in Switzerland to wholesale dealers in other countries, or to producers in other countries. This price includes not only the production costs, but also all intermediary markups along the supply chain, which can vary significantly, depending on the structure of the supply chain.

Figure 6: Import prices in kg/EUR for cannabis resin along the supply chain from Morocco to the Netherlands[30]



Sources: in 2012 €. Created by Kilmer and Burgdorf and based on data from Afsahi, 2011; Bussink et al., 2007; Gamella & Jimenez Rodrigo, 2008; UNODC, 2006, 2007, 2012;

[30] Reproduced with kind permission from Kilmer & Burgdorf (2013).

and Niesink et al. 2010, as cited in Van Laar et al., 2011. Imp. = imported, MR=Morocco, ES=Spain, NL=Netherlands.

As an example I will describe a “short” supply chain. If a group of cannabis dealers in Switzerland has established connections to producers in the Balkan region, they could potentially buy a kilo of wholesale marijuana relatively close to prodcution costs between 500-2,000 CHF depending on the connection, volume and bargaining power. They could then potentially smuggel this product into Switzerland themselves and sell it at retail value for about 10,000 CHF and reap in the benefits of 8,000 – 9,500 CHF to cover their costs and risks.

A long supply chain could for example be a group of local dealers from Switzerland who regularly buy from a wholesale-importer in Switzerland. This importer travels to Belgium or the Netherlands, where they buy wholesale cannabis at 4,000-7,000 CHF. This cannabis could have previously been produced somewhere in north africa, was sold at a markup to be imported into the EU in Spain where it was resold at another markup to wholesale dealers in the Netherlands, where it was finally sold to a Swiss wholesaler to be imported into Switzerland where it is again resold to retail dealers in the Swiss market. In this example, the import prices for a kilo of marijuana that the retail dealers pay would probably be closer to 6,000-8,000 CHF, again depending on the actual structure of the supply chain.

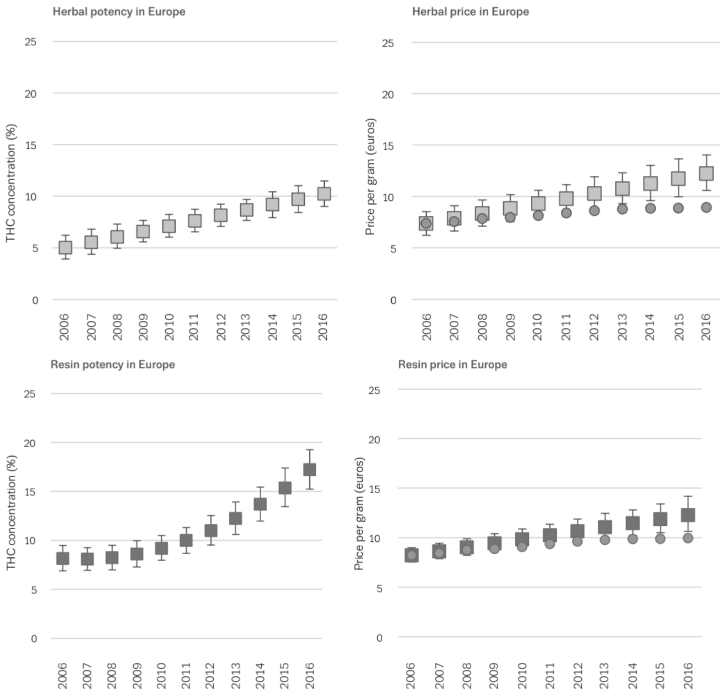
Both cases are grounded in reality and could very well exist like this in the Swiss market. Since the bandwith for import prices is so wide and there is very little information on the actual structure and volume of the cannabis import, I used a combined estimate of UNODC data for wholesale cannabis in Switzerland from the World Drug Report (United Nations Office on Drugs and Crime, n.d.), and validated these values by expert input from the police interviews and reference data from the European wholesale market (European Monitoring Centre for Drugs and Drug Addiction & Europol, 2019, p. 84). For the estimation I use resulting import prices of 5.391 CHF for a kilo of marijuana and 4.976 CHF for resin.

3.7.5 Retail prices

There is little statistical information available on the retail value of illegal cannabis in Switzerland. While the ministry for police did for some years publish estimates by the cantonal and city police forces, it ceased to do so around 2014, when they published their last estimate of 11 CHF/g for marijuana (Federal Office of Police fedpol, 2014, p. 34). The information gathered by police forces is probably a relatively reliable indicator, as they investigate hundreds of cases annually all across Switzerland. Therefore, I have also asked about retail prices for marijuana and resin in our interviews with narcotics expert from the police. For marijuana, all police forces I talked to mentioned price ranges of between 8 – 20 CHF with a clear focus on averages between 10-12 CHF. Less than 10 CHF is usually only paid for poor product quality or when buying in bulk (discounts). More than 12 CHF is extraordinary too and is only paid for very "premium" products or in special circumstances (e.g. temporary monopolies or supply shortage). Resin seems to be slightly more expensive, average prices were mentioned between 11-15 CHF/g. Based on this information I have decided to use 10 CHF/g for marijuana and 13 CHF/g for resin.

Both prices seem to have been stable over recent years. Research in the early 2000s, almost two decades ago, already mentioned prices of about 10.50 CHF/g for marijuana (Isenring & Killias, 2004). The stability of domestic prices is a bit surprising, when comparing it to international developments (European Monitoring Centre for Drugs and Drug Addiction, 2019). While the potency of both marijuana and resin in Europe have almost doubled between 2006-2016, the average prices have also increased significantly over the course of a decade (for marijuana from around 7 EUR in 2006 to 12 EUR in 2016 and for resin from around 8 EUR in 2006 to 12 EUR in 2016) (ibid. pp. 6-8).

Figure 7: Changes in potency and price of herbal cannabis and resin in Europe 2006-2016[31]



Note: Data show means (+- 95% confidence intervals) for estimated trends after accounting for variation across countries. Expected changes based on inflation of consumer goods are shown in red circles.

One hypothesis, for the relative stability of marijuana/resin prices in Switzerland lies in the domestic market structure. Some narcotics experts at the police forces I spoke with mentioned, that in general the regional and national market is very much demand driven. They argue that the demand is met very quickly by an agile domestic market combined with significant imports and supply

[31] Reproduced with kind permission from European Monitoring Centre for Drugs and Drug Addiction. (2019, pp. 6, 8).

shortages, which could affect prices, occur very rarely. With a fairly stable demand, price changes would only be expected if there were significant changes in the supply structure or in production/import costs, which has not been the case.

3.7.6 Valuating police seizures

To valuate the seizures made by police and border patrol forces, it is necessary to know, at what stage of the supply chains the seizures were made. While the PKS does provide quite detailed classifications on the sort of product seized (e.g. seed, sapling, fresh plants with buds, dried plants, etc.) it does not provide additional information on the context of the seizure (e.g. raid on production facility, arrest of dealer or consumer) (Federal Statistical Office, 2021d). To circumvent this lack of data it is necessary to approximate a distribution of seizures between the stages of the supply chain. For this purpose, the BFS kindly provided us with a specific analysis of the PKS data for 2018. This data contains not only the number of seizures as well as the aggregate weight of the products seized, but also class data on the weight of the individual seizures. This additional information allows us to develop an approximation of seizures by weight. To do so I group the products into three categories:

- Pre-harvest products (seeds and saplings)
- Harvest products (fresh plants with buds, dried plants)
- Market products (processed and/or packaged marijuana and resin in retail quality)

Pre-harvest products were disregarded for the purpose of this estimation. The reason for this decision is that while there is a market for these products and they are traded amongst cannabis producers and could be valuated at current value, there is not sufficient data on the production process to determine the future discounted retail value of these intermediary inputs. Several factors such as fertility, seed quality, the degree of germination, thinning, risk of seizure, etc. would need to be accounted for which would be beyond the scope of this project. An additional reason for the decision is the comparably low case numbers for these products. Seeds and saplings only account for about 5%-10% of all seizure cases (with fluctuations from year to year). Albeit this information obviously does not take a valuation of said products into account. Since these products are not included in the estimation, the real value of seizures is probably higher than our estimate.

The two forms of harvest products are treated differently. While dry plants are counted with their seizure weight, fresh plants are adjusted with an evaporation factor of 67% to account for the weight loss during the drying process (Warner et al., 2017, p. 55).[32]

Retail products are counted at their weight at the time of the seizure. Since the goal is to differentiate the seizures with respect to their current value, it is necessary to make an assumption concerning the share of seizures that has already been traded at retail value and the share which is taken out of the supply chain before it reaches the retail market. To do so, I analysed the volume of seizures with respect to the total weight of the seizure and set a threshold of 53 grams[33] which corresponds to about 20% of the annual consumption of an average very frequent consumer (≥20 consumption days within the last 30 days) or about 250 joints, using an approximated value of 0.2g per joint (using the simplified assumption that the entire volume is consumed by smoking) (Zobel et al., 2020, p. 12). While the threshold is somewhat arbitrary,

[32] This estimation might overestimate the true value if a significant share of the seizure weight would be discarded as waste. The United Nations Office on Drugs and Crime (2008) for example estimates a 10-3-1 ration from fresh plants, to dry plants to product yield. However, this ratio can differ depending on the product quality (e.g. volume can be inflated by including seeds/branches) and plant type (sinsemilla and non-sinsemilla). Additionally, it is not possible to discern from the PKS data whether only processable plant segments are counted or the entire weight of the plant.

[33] 53g represents the median value of the seizure group between 6-100 grams and was selected assuming a gaussian distribution.

the assumption was validated during our expert interviews with cantonal police forces who conduct the operations behind these statistics.

Table 5: Cannabis seizures PKS 2018 by weight group[34]

	<1 g		>=1-<6 g		>=6 - < 100 g		>=100 g	
	Nr. of seizures	**Weight in kg**	**Nr. of seizures**	**Weight in kg**	**Nr. of seizures**	**Weight in kg**	**Nr. of sei-zures**	**Weight in kg**
Fresh Plants	*	0.001	*	0.01	10	0.41	16	34.48
Dried Plants	*	-	*	0.03	29	1.03	42	32.26
Hashish (resin)	1072	0.474	2192	5.63	1592	42.65	264	626.51
Marijuana	2703	1.002	6025	17.35	3789	102.45	882	1281.83
Sum		**1.48**		**23.04**		**146.56**		**1,975.1**
Share of total		0.07%		1.07%		6.83%		92.03%

**concealed values due to very low sample size*

By this estimation method, 95% of the marijuana and resin seized is valued at production value, while 5% is valued at retail prices. The sensitivity of the 53-gram threshold is relatively low. Decreasing the threshold to 5 grams would only change the retail/production share from 95% to 98%, increasing it to 100 grams would change the retail/ production share to 92% respectively. Using this approach, it cannot be ruled out, that some seizures below the threshold do actually stem from production operations, at the same time, it cannot be ruled out, that some seizures above the threshold are not actual production operations, but larger amounts for private consumption or stemming from home-grown operations. However, as the sensitivity analysis shows, most of the volume seized (more than 92%) is seized in amounts larger than 100 grams. During our expert interviews with cantonal police

[34] The data was provided by the federal statistical office in personal communication (P. Hayoz, personal communication, 7.1.2020).

forces it was also confirmed, that amounts on this level are almost always encountered in production or trade operations. Based on this argument, I calculate half the seizures smaller than 54g at retail prices and half at production value, under the assumption that they are partly seized on the consumer level and partly at retail trade level of smaller dealers. Seizures of 54g and more are entirely valued at production value based on the assumption that they are taken off the market before they reach the final demand.[35]

An additional factor that needs to be considered, is the amount of cannabis produced in home-grown operations for personal use. To account for this, I am again using data from the European Web Survey on Drugs analysed by Zobel et al. (2020, p. 64). The survey also asked respondents how they obtained the cannabis they consume and thus provides reference data for the share of home-grown cannabis. The share differs amongst consumer groups, which is not surprising, given the reasons found by research on the topic on home-growers.

> "Overall, the top five reasons for growing cannabis were, in order, 'It provides me with cannabis for personal use' (84%), 'I get pleasure from growing cannabis' (83%), 'It's cheaper than buying cannabis' (75%), 'To avoid contact with the illegal circuit (e.g. street dealers, criminals)' (72%) 'The cannabis I grow is healthier than the cannabis I buy' (68%)" (Potter et al., 2015, p. 8)

An additional reason, which was only available for selection in German speaking countries (including Switzerland) though, is the fact that the final product would not contain any adulterants. This reason about the "organic" quality of the product ranked first in both Germany and Austria and was the third most cited reason in Switzerland (ibid.). When considering these reasons cited for picking up and operating home-growing operations, it seems clear, that these would increase with the amount of cannabis consumed.

[35] Estimating larger seizures at production value is probably underestimating the total value slightly, as it is possible, that a share of these seizures happens at wholesale level and have thus been traded at a mark-up already.

More personal demand, more potential saving when comparing to buying from the illegal market, more frequent contact with dealers are comprehensible arguments for considering growing.

These hypotheses are confirmed by the data. The largest share of respondents claiming to source their marijuana from producing it themselves are very frequent consumers with 13% (more than 20 days in the last 30 days) followed by frequent consumers (10-19 days in the last 30 days) with 8% and regular consumers (4-9 days in the last 30 days) with 6% (Zobel et al., 2020). Consumers with 1-3 consumption days in the last 30 days claim the smallest share with only 2% of respondents. The degree of home-grown marijuana sourcing increases to 6% again for the group of consumers who claim consumption within the last 12 months, but not within the last 30 days (ibid.). Weighting these shares by their respective volumes yields an average of 8% of the consumption volume being produced by home-growers. It remains unclear, what the dimension of home-growing operations is (see the discussion by Zobel et al., 2020, pp. 97-98). The scale ranges from small-scale single plant operations that need to be complemented with illegal-market purchases for covering personal use to larger, indoor and outdoor production with multiple harvest per year that can sustain not only personal consumption but can also provide friends and acquaintances on a commercial or not-for-profit basis.

As the spectrum of growing operations can a-priori both over- and underestimate the actual share of home-grown cannabis in the market, I will use simplified assumptions for the sake of this estimation. The first assumption is that the volume of home-grown marijuana corresponds to the share of respondents per consumption group (production only covers the entire personal demand and is not commercially distributed). The second assumption is that the share of home-growers is evenly distributed throughout the consumption groups.

Since the production and/or trade of cannabis can, depending on the scale and context, quickly lead to legal consequences in Switzerland, it is very likely, that the data quality on this phenomenon is worse than for the consumption data, if we assume that survey-based underreporting of both phenomenon is at least partially based on the social stigma and the severity of potential (legal) consequences. Some share of this presumed underreporting is already adjusted for by the literature-based adjustment factor for consumption. when dissecting the underreporting effect, it contains four different groups with regards to home-grown operations:

- Respondents who consume and grow at home and decide not to participate
- Respondents who consume and grow at home and do not report either
- Respondents who consume and grow at home and only report consumption[36]
- Respondents who consume and grow at home and report both

Theoretically there would also be a group of respondents who do not either/or consume and produce but still claim to do so. While this cannot be ruled out, the effect is probably small, given the stigma associated with the topic. The same is true for people who do not consume cannabis but produce at home, since this situation would most likely have a commercial background and scale and thus be captured in the wholesale operations.

Because I only have data on group 4 and the literature-based adjustment factor is only capturing underreporting of consumption, there are two things to consider. The first is that the actual share of people consuming (and growing) and concealing it might be higher due to self-selection bias (group 1). This is also what Zobel et al. (2020) suspect as one hypothesis for the difference between the survey-based estimate and the WBE estimate. The second is that the degree of underreporting of home-growing might be larger, than it is for underreporting of consumption (due

[36] Or underreport consumption (Morral et al., 2000).

to groups 1 and 3). While some of this uncertainty is captured by the additional adjustment of the estimated volumes regarding the WBE estimate, I suspect that my estimate for home-grown volume is still probably underestimating the true dimension.

Unfortunately, there is no information on the share of home-grown marijuana for police seizures. To circumvent this issue, I deduct the weighted average for the consumption volume to the retail level seizures, to control for homegrown marijuana in the valuation process. Since the estimation assumes that there is no (wide) distribution of the home-grown products, the homegrown volume is valued at production costs. Following the assumption that resin is imported from abroad, no estimation for a home-grown share of resin is necessary.

3.7.7 VALUATING CONSUMPTION AMOUNTS

The valuation of the consumption volumes of both marijuana and resin follows a similar methodology as used for the valuation of seizures. For marijuana I deduct the share of homegrown marijuana which is valued at production costs whereas the remainder of the volume is valued at retail costs. For resin again no homegrown share is deducted since the estimation assumes that the entirety of consumed volume is imported from abroad and valued at retail costs.

3.8 RESULTS: CANNABIS MARKET

Combining the estimations for both the volume (3.1.1) as well as for the various prices (3.1.2) it is now possible to calculate the value of the cannabis market in Switzerland. Table 6 shows the results for both marijuana and resin. Based on the data and assumptions outlined in the previous chapter the total revenue for marijuana is estimated to be around 365m CHF annually and resin amounting to about 217m CHF.[37] Aggregated the total revenue for marijuana and resin amounts to about 582m CHF annually.

Table 6: Total value and revenue marijuana and resin market in Switzerland (in m CHF)

	Marijuana	Resin
Homegrown production	5.5	0
Retail value*	361.8	217.4
Domestically produced	*242.4*	0
Imported	*119.4*	217.4
Seized value (prod. and wholesale)	7	2.6
Domestically produced	*2.8*	0
Imported	*4.2*	2.6
Total value	**374.3**	**220.1**
Total revenue**	**364.6**	**217.4**

** includes retail seizures*
***excludes homegrown production and seizures at import value*

Whether or not homegrown production should be included in the national accounting aggregates remains an open question. Based on available information (Potter et al., 2015, p. 182), the degree of commercial intent/activity behind this volume is negligible though. In addition, other forms of household production such as gardening for self-sustenance are not included in the national accounts either. As a simplified assumption I am thus treating this value the same way as other forms of household

[37] The data used for the estimation is mostly from 2016-2018 since this is often the most up-to-date information available (see chapters 4.2.2 and 4.2.3). The population data used for the consumption estimate is based on 2017.

production (e.g. growing potatoes in your backyard) and do not include it in the calculation of gross output.

In addition, it needs to be noted, that some aspects of the cannabis market are not included in this estimate as there was no data available. This includes for example the costs of cannabis consumers for cannabis paraphernalia such as rolling paper, pipes, water pipes or vaporizers. Including these would further increase the estimated market size.

3.8.1 BREAKING DOWN REVENUE INTO ITS ECONOMIC COMPONENTS

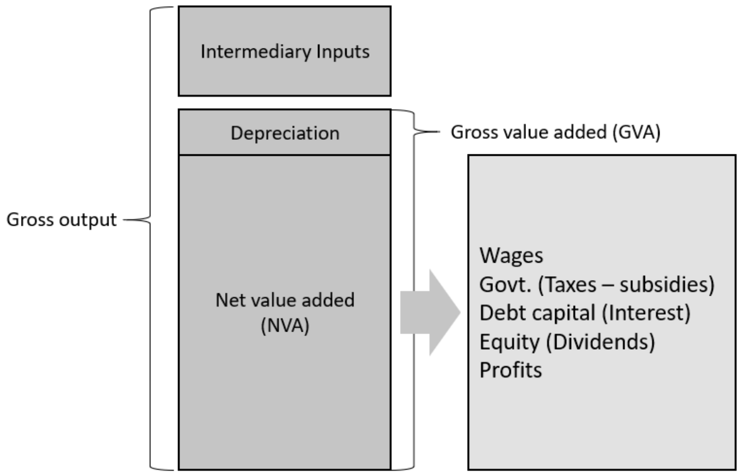
While the revenue is a helpful aggregate for understanding the dimension of the market, it is necessary to break down the revenue into its economic components for further analysis. This enables us on the one hand to simulate different effects of alternative regulatory scenarios (see Chapter 5). On the other hand, the disaggregation allows for the simulation of the total economic effects of the cannabis system in Switzerland (see Chapter 4). Finally, only when looking at the disaggregated components it is possible to identify which share of the economic activity in the cannabis market is illegal and which is legal.

To make these results comparable to the national accounting system in Switzerland it is necessary to break down the domestic revenue into four components:

- Domestic gross output, which corresponds to the total value of the cannabis systems output
- Imports which correspond to goods and services imported from abroad
- Intermediate inputs, which correspond to goods and services that are used in the production process for any given good or service used up by final demand

- Gross value added, which corresponds to the gross output less the intermediate inputs (see Figure 9)

Figure 8: Economic components of gross output



3.8.2 MARIJUANA

To disaggregate the total revenue for marijuana (365m CHF), it is necessary to calculate the respective shares of intermediate inputs and value added.

For the domestic production (242m CHF) this is done by using the estimated average production costs (chapter 3.1.2). The result are the estimated intermediary inputs required to produce marijuana in Switzerland (42m CHF). It is important to consider, that these are only external costs of the production process (e.g. rent, energy, equipment). Labour costs are explicitly not part of this estimate and are instead part of the value added. In addition to the production costs, based on similar estimates by Eurostat countries (Kazemier et al., 2013; Magnusson Wärmark et al., 2008) and interviews with industry professionals, I assume a share of 5% of the trade margin as additional aggregate costs for the trade and sales process. These costs include things such as logistic, storage, security and telecommunication and amount to 10m CHF for the domestic marijuana production when applied to our estimate. The remainder of the domestic output (190m CHF) constitutes the gross value added and consists primarily of wages and profits of the organisations and people involved in the various steps of the supply chain. In a legal setting, the value added would also include taxes paid, depreciation and return on capitals, however in an illegal market these factors do not exist in the traditional sense.

The imported marijuana is treated similarly. With the exception, that as the production costs occur outside of Switzerland, instead the estimated import value is deducted (64m CHF) and trade and sales intermediary inputs (3m CHF) leaving us with a domestic net trade margin of 52m CHF.

Wholesale seizures at import prices (4.2m CHF) are assumed to never reach the market in Switzerland and are thus not part of gross output. They are part of imports though and are comparable to import losses incurred by the importer (e.g. rotten produce). Wholesale seizures at domestic production prices (2.8m CHF) are treated the same, as they correspond to a business loss without any connected revenue.

3.8.3 Resin

The resin market is treated the same as the marijuana market, except that the estimation is based on the absence of a domestic production. The resulting values for the components are shown in Table 7 and Table 10.

3.8.4 Concluding remarks

Chapter 3.1 presents the estimation for both the quantity of marijuana and resin in the Swiss market for recreational cannabis as well as the valuation of the estimated quantity for both consumption as well as quantities seized by police forces. Overall, I estimate a domestic revenue of around 582m CHF for the Swiss cannabis market. Adjusting for imports and seizures, the resulting gross output in Switzerland amounts to 432m CHF. The total import value in the status quo is estimated at about 154m CHF.

When considering only value added, the estimated 370m CHF make up about 86% of gross output for the cannabis market. This is a very high ratio and is caused by the large profit-margins for illicit cannabis products both domestically produced as well imported from abroad.

Table 7: Economic aggregates for marijuana and resin (in m CHF)

	Marijuana	**Resin**
Domestic Revenue/Consumption	364.6	217.4
Gross output	297.5	134.2
Trade and sales costs (dom. prod.)	10.0	0.0
Value added (dom. prod.)	190.0	0.0
Import costs	68.6	85.9
Trade and sales costs (imports)	2.8	6.7
Trade margin	52.3	127.5

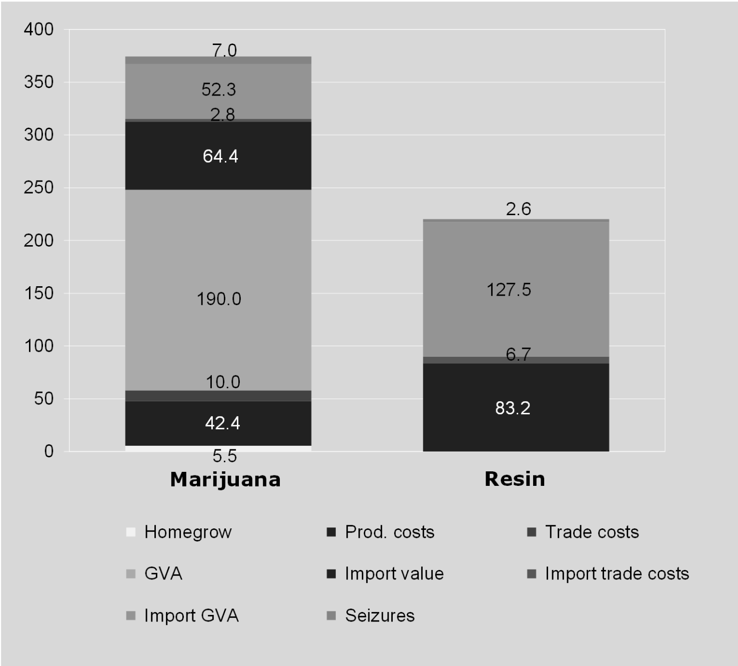
Police seizures, following our valuation method account, account for just about 2% of the market valuation for marijuana and about 1% for the resin market. This, however, does not mean that they are, economically speaking, of negligible importance. On the contrary, while the economic value associated with seizures might be comparably low, the risk of detection and associated legal consequences is an influencing factor in both production- as well as import costs and one of the reasons, why the profit margins of illegal need to be as high as they are, to still create viable incentives for producers and traders (G. S. Becker et al., 2004).

Table 8: National accounting variables for the Swiss cannabis market (in m CHF)

	Cannabis
Domestic Revenue/Consumption	582.0
Gross output	431.7
Imports*	154.4
Intermediary Inputs production	42.4
Intermediary Inputs trade and sales	19.5
Gross value added	369.8

**includes the import value of both final demand and seizures*

Figure 9: Breakdown of the marijuana and resin market into economic components (in m CHF)



The estimation conducted in this chapter is subject to limitations both with respect to the data that is used, as well as with respect to the methodology used. Some limitations, such as the issues associated with survey-based research on illegal goods, are unlikely to be remedied, unless the legal situation on cannabis changes. However, there are other aspects that would improve the accuracy of this estimation. One such approach, would be to continue the research path taken by Zobel et al. (2020) and extend wastewater analysis to other regions in Switzerland, or potentially even to the national level with corresponding survey based date on the same geographical regions and timeframes. With additional improvements in the methodology and experiences from other analysis in Europe and worldwide (European Monitoring Centre for Drugs and Drug Addiction, 2020c; Zuccato et al., 2016) it might be possible to continue to improve quantity estimates for cannabis and other drugs. Other aspects, that would be beneficial to this research topic are related to the economic side of the Swiss cannabis market. There is unfortunately very little information on the market structure, import shares, costs and routes and domestic production. This is also true on the individual perspective. Data on transactions, prices, quality, consumer preferences and attitudes etc. is sparse to non-existent and would benefit future estimations greatly. One such approach could be non-representative studies that explicitly address cannabis consumers, producers, etc. (see Barratt et al. (2017) for one example for such an approach: the Global Survey on Drugs). Another approach that would allow for the collection of transaction data is crowdsourced data collection as it for example being done in the U.S. and Canada (see for example priceofweed.com).

This chapter presents the data and methodology used to valuate the cannabis market in Switzerland as well as limitations of the approach and suggestions for further research. However, the cannabis market – while being the largest individual segment – is only one of five segments under investigation in this project. A different area of economic activity related to cannabis is the healthcare sector, which is subject of the following chapter.

3.9 Healthcare and treatment

The second segment of the cannabis system which this project addresses, is healthcare and treatment. There are several activities in the healthcare system that are linked to the consumption or overconsumption of cannabis. Each year, the economy needs to produce goods and services that are required to treat patients, who need help in dealing with adverse social and health outcomes related to the consumption and/or abuse of cannabis. These activities include for example the work of doctors, nurses, administrative personnel, insurance companies, psychosocial institutions for addiction counselling or the provision of medicine and counselling.

To quantify these effects, it is important to first determine, which of these activities are causally attributed to cannabis consumption or regulation. Since cannabis consumption is considered to be a risk factor for various adverse social and health effects (Hall, 2015; Levine et al., 2017; National Academies of Sciences, 2017; Weiss et al., 2017; Wilkinson et al., 2016), but seldom the sole causing factor, this task is of particular relevance. The cost-of-illness (COI) methodology uses attributable fractions (AF), to determine the fraction of outcomes, that can be attributed to an underlying cause (such as cannabis consumption). These are conceptually speaking calculated using the share of people consuming cannabis/addicts based on the total population and using the relative risk for a negative outcome (e.g., a disease) of this group compared to people who do not consume cannabis/are addicts. However, while this approach is generally considered the best way to approach the issue of causality for the topic under investigation here, when faced with reality there are significant challenges to the application. The single and most obvious being the lack or quality of data and evidence available. For the vast majority of health outcomes, there is no scientific consensus, as to what the AF for cannabis consumers/addicts are. The seminal and most up-to-date inventory of the relationship between cannabis consumption and health outcomes has been summarized by the National Academies of Sciences (2017), Hall (2015) and Levine et al. (2017). They summarized the current state of research on cannabis consumption and a host of health outcomes such as cancer, respiratory diseases, injury and death, psychosocial and mental health. While there is often no doubt about the *correlation* between cannabis consumption and a number of health outcomes, there is significant uncertainty about the causality of this relationship, because a large share of studies on the subject are unable to control for cofounding variables.

Table 9: ICD-10 Codes included in the analysis

Diagnosis Code	**Group Description**	**Specific diagnosis**
F12.0	Cannabis abuse and psychotic disorders:	Acute intoxication
F12.1	Cannabis abuse and psychotic disorders:	Abuse
F12.2	Cannabis abuse and psychotic disorders:	Dependence syndrome
F12.3	Cannabis abuse and psychotic disorders:	Withdrawal syndrome
F12.4	Cannabis abuse and psychotic disorders:	Withdrawal syndrome incl. delirium
F12.5	Cannabis abuse and psychotic disorders:	Psychotic disorder
F12.6	Cannabis abuse and psychotic disorders:	Amnesic syndrome
F12.7	Cannabis abuse and psychotic disorders:	Delayed psychotic disorder
F12.8	Cannabis abuse and psychotic disorders:	Other form of abuse or psychotic disorder
F12.9	Cannabis abuse and psychotic disorders:	Unspecified abuse or psychotic disorder

In Switzerland economic data on the costs of cases in hospitals is gathered by the federal statistical office based on data from the hospitals linked to the SwissDRG network (SwissDRG SA, 2019). This sample of network hospitals, however, does not cover *all* hospitals and/or healthcare facilities in the country but rather only the general hospitals ("akutsomatische Krankenhäuser"). This is of particular relevance, as especially institutions whose focus is psychiatric and psychological care are not yet included in this statistic.[38] Since these institutions are very likely to process most of the cases in the diagnostic code groups under investigation, the data I obtained from the "case cost statistic" represents a lower-boundary estimate and must be interpreted with respect to this caveat.

Table 10: SwissDRG case cost data[39]

ICD-10 Codes: F12.0-F12.9	**Nr. of discharges**	**Weighted sum of case-cost means in CHF**
2017	59	220,317
2018	64	224,648
2019	98	311,449
3y-avg (2017-2019)	*73.7*	*252,138*

As with the other data sources in this report, I used the most recent data sources available at the time of analysis and calculate a multi-year average to smooth out individual year-to-year data fluctuations. Doing so yields average annual costs of about 252K CHF in treatment costs for cases over the period 2017-2019 in the general hospitals in Switzerland.

There are two main reasons, why this is not the entirety of the economic activity in the healthcare system. The first being, that the diagnostic code in this statistic is only considering the *main* diagnosis. In other words, cases where a diagnosis related to cannabis was prevalent but was not the main issue, are not considered. While this is a weakness of the data that is available, even if it were available, not including these cases is in line with the methodology

[38] While the relevant data of these institutions is already collected by the SwissDRG, it was not yet available or published by the BFS at the time of this project. However, according to the BFS this data will be available in the near future and can be integrated in future research.
[39] Due to the small number of cases in individual diagnostic codes we publish data only aggregated for the entire diagnostic group (F12) following FSO data-privacy guidelines.

used in the health economics literature for similar estimations and the rationale is outlined in the beginning of the chapter.

On the one hand, the general hospitals covered in this statistic by the nature of the swiss healthcare system tend to focus on acute cases. Long-term measures, therapies and less acute cases are usually covered in more specialised institutions working specifically on addiction and its consequences. Additionally, the hospitals usually cover mostly medical and psychiatric cases. Other interventions such as psychosocial and psychoeducational measures, while also offered in general hospitals, are also provided by other, non-hospital institutions.

Unfortunately, there is no coherent data-source available in Switzerland, that covers the economic effects for *all* institutions working on addiction issues. However Addiction Suisse runs a monitoring network *«The information network on addiction care and therapy in Switzerland»* that covers five different areas of addiction therapy and counselling (Addiction Suisse, 2020):

- SAMBAD (Ambulant counselling and treatment for alcohol addiction)
- act-info-Residalc (Stationary counselling and treatment for alcohol addiction)
- act-info-FOS (Stationary addiction therapy)
- HeGeBe (Heroin based treatment)
- Methadon (National methadone statistic)

As part of their activities, they conduct an annual survey of the vast majority of institutions offering ambulant and stationary addiction treatment and counselling in Switzerland (Maffli et al., 2021) which conceptually excludes general hospitals covered in the Swiss DRG case cost data, but does not exclude medical institutions specialised on addiction (which sometimes can be organisationally adjoint to general hospitals).[40] Given this uncertainty, it cannot be ruled out, that there might be some overlap between both datasets. Based on the setup and aim of the institutional survey by Addiction Suisse, this overlap is probably small. For this reason, I have decided to use both datasets (case cost data and Addiction Suisse institutional survey) in conjunction and accept this caveat.

While the focus of the institutional survey is not economic in nature and in its standard form would not provide data necessary for the research question of this project, in 2018 a prototype survey was conducted, that included, amongst other indicators, questions on the full-time-equivalents (FTEs) of the institutions involved in the monitoring. Even though the prototype was primarily conducted for methodological reasons, Addiction Suisse kindly provided us with the primary data gathered in this prototype survey to use in this project. Since the survey was reorganized in 2018, there are some methodological issues which need to be accounted for (Maffli et al., 2020 pp.12-16).The sample for the prototype survey contained data for a total of 293 returned surveys, which is about 74% of the total number of 394 institutions that were identified for this survey (Maffli et al., 2020 p.14). Cleaning the sample to contain only institutions who provided information on their FTE numbers and aggregating institutions, where different parts of the same institutions answered the survey, a total of 245 answers remained. There are three relevant variables in the questionnaire, for the purpose of the analysis:

- The type of institution (ambulant, stationary, both, practicing doctor, prison, other)
- The total amount of FTE in the organisational unit that the survey was addressed to

[40] The sample for this survey was constructed using the database at suchtindex.ch (Maffli et al., 2020, p. 14).

- The total amount of clients who have entered or re-entered the institution in 2017 distinguished by their *main* addiction problem

For the analysis of the data, Etienne Maffli of Addiction Suisse provided expert input and interpretation of both the survey and the data which helped significantly to improve the results.[41] The aim of the analysis was to approximate the economic resources required annually to provide cannabis-related healthcare interventions in treatment, care and counselling. To do so, and because there are significant structural differences between institutions working in a stationary vs. an ambulant setting, I have first separated the sample into the different types of institutions.

Table 11: Addiction Suisse institutional prototype survey

Type of institution	**Nr. and percentage of answers**		**Nr. of patients (re)entries with cannabis as the main problem**
Ambulant	143	*58.4%*	3,372
Stationary	59	*24.1%*	253
Hybrid (amb.+stat.)	23	*9.4%*	223
Practicing doctor	1	*0.4%*	7
Other	16	*6.5%*	42
Not specified	3	*1.2%*	1

Subsequently the last three categories were dropped, since the (re)entry numbers only make up only about 1% of all cannabis cases and the number of answers was too low, to calculate meaningful averages for these categories. Just by looking at the data it is obvious, that with almost 4,000 patient (re)entries compared to the roughly 70 cases in the case cost statistic the institutions

[41] The author expresses his sincere gratitude for both the provision of the data and the additional support with this estimation to Addiction Suisse in general and Etienne Maffli in particular.

covered in this survey cover are far higher number of cannabis centred healthcare interventions.

Addiction Suisse pointed out, that the resource intensity between cases varies between substances or addiction types. Simply calculating type specific averages per form of addiction would thus likely distort the results. Since the prototype survey did not provide any information on FTEs per form of addiction the only option to weight the case numbers was using the relative cost weights from the case cost statistic. While there are obvious limitations to this approach, the most immediate being that the cost weight between different forms of addiction might be different between a clinical/hospital setting and other healthcare institutions, another might be that the forms of treatment could also differ between the two statistics. Nonetheless, after deliberation I decided that the differences between both statistics probably does not outweigh the alternative of not weighing the cases at all. For this reason, the case numbers were weighted by their relative cost factors from the case cost statistic and then calculated average FTEs per (re)entry per type of institution per form of addiction for all institutions who gave an answer to the FTE question.

Table 12: Case cost weighted FTEs per form of addiction per type of institution

Type of institution	Alc.	Can.	Opi.	Co-caine	Other	Sum
Ambulant	459.6	53.0	229.6	33.6	330.3	**1,106.2**
Stationary	308.3	52.6	154.2	106.6	169.8	**791.5**
Hybrid	374.2	16.5	82.5	17.9	118.4	**609.5**
Sum	**1,142.1**	**122.1**	**466.4**	**158.1**	**618.5**	**2,507.1**

As pointed out, there are limitations to this analysis and in the coming years, if more detailed data becomes available, a more refined and precise estimate can surely be achieved. However, based on the data that was available at the time of analysis, I estimate that the institutions covered in this prototypical sample jointly require about 122 FTEs annually to provide the services required for the treatment of cannabis centred cases. Again, following the initially discussed methodology, the analysis focuses on cannabis centred cases only. Other cases, where cannabis was involved but not the main problem, are not included. I decided not to extrapolate the data for the remaining institutions without an answer, as there was no information on the structure of the sample available to do so. The estimate is thus definitely a lower-boundary estimate and the real number could be higher.

To convert the FTE into monetary terms, I used industry specific labour productivities for the healthcare sector (Federal Statistical Office, 2020a).

3.9.1 Additional activities in the healthcare sector

It is important to note, that the data captured in this estimation primarily deals with the more or less formal treatment and counselling of people facing adverse health effects from cannabis consumption. There are many other activities by a wide spectrum of institutions that go beyond the immediate treatment and counselling of cannabis consumers, for example in primary, secondary, and tertiary prevention[42]. These activities include but are not limited to school programmes, social work in all its facets, sport, and other youth programs, assisted living facilities, etc. While some of

[42] Primary prevention refers to activities before adverse health effects or problematic behaviours occur, secondary prevention deals primarily with the early detection of adverse health effects or problematic behaviours and aims to end or remedy the problems. Tertiary prevention on the other hand takes place if adverse health effects or problematic behaviours are already happening and aims to prevent additional damage and relapses. (Addiction Suisse, 2013).

these activities are captured in the analysis of the institutions covered by Addiction Suisse, the list is likely not exhaustive.

In an initial approach to estimate these effects, I tried to capture these activities by using a survey-based snowball-approach to data collection. By contacting the cantonal offices for public health I identified institutions possibly conducting cannabis-related activities in prevention on the local, regional, cantonal or intercantonal level covering the cantons of AG, BE, BL, BS, FR, GE, GR, LU, NE, SG, SO, TG, VS and ZG. The identified institutions were contacted and asked to briefly describe their activities as well as their relation to cannabis-related activities. In addition, they were asked if they coordinate with or are aware of other institutions working on cannabis-related issues to further increase the sample. Using this approach, I identified a total of 210 institutions or organisational units of which 48 answered our questions in a first wave (response rate 24.2%). Several institutions did not actually deal with cannabis-related issues (e.g. because they focus solely on another form of addiction) and were thus omitted in the analysis. In addition, the answers of the remaining institutions revealed several methodological issues for the estimation.

The institutions that did indicate to work with cannabis-related issues most of the time did so without a specific focus on cannabis, without cannabis being the main issue of their work and/or without the ability to quantify the share of their activities related to cannabis. When pressed for a qualitative assessment the answers were usually less than 5%, if at all. One hypothesis why this might be the case was indicated by some qualitative interviews I conducted with participants. It was often mentioned that those institutions, who work in general social work and general prevention work, do so mostly by addressing the entire spectrum of addictive substances and behaviours. In addition, there are institutions who work specifically on particular substances (often alcohol and tobacco) who mentioned that cannabis consumption does play a role in their work but usually as comorbidity and not as the main problem. Some institutions also indicated that the illegal nature of cannabis does play a role in their focus (or lack thereof) on specific forms of addiction. Based on the initial results from this approach I have decided to discontinue with the data collection, as it was foreseeable that it would not be possible to discern a reasonable estimate for cannabis related activities from the underlying organisational structure of additional activities in the healthcare sector using this methodology. In addition, the preliminary data suggests that the economic effects associated with these activities are likely of a negligible dimension.

3.9.2 Concluding remarks

Chapter 3.9 presents the estimation for cannabis related activity in the healthcare sector. Overall, I estimate direct gross output of about 22.5m CHF for the activities of both general hospitals as well as ambulant and stationary addiction help institutions.[43]

When interpreting this result, it is important to keep in mind, what this estimate encompasses. This estimate does not include all activity in the healthcare sector, where cannabis is involved or plays a role for the intervention. There are cases where adverse health effects related to cannabis usage might be a comorbidity, but not the main diagnosis. There is also activity in ambulant and stationary addiction help institutions, where cannabis might be consumed by patients, but it is not the reason for their treatment. There is also activity in social work and prevention, that deals directly or indirectly with cannabis, but is not quantifiable with the existing data. All of these limitations indicate that this estimation is probably a lower boundary estimate that relies on a narrow definition of cannabis induced healthcare effects.

The question which health outcomes are to be attributed to cannabis consumption and which are not, is an ongoing debate in the medical field (Degenhardt et al., 2018; Fischer, Mäder, et al., 2020; Hall, 2015; Levine et al., 2017; National Academies of

[43] Activities by institutions specifically and solely focused on preventative work were omitted for methodological reasons.

Sciences, 2017). If the knowledge on the relation between cannabis consumption and adverse health outcomes improves, it will be necessary to adjust the estimation methodology in the future.

Table 13: Economic resources required annually by the healthcare sector for cannabis centred interventions

Category	Gross output (in m CHF)	Value added (in m CHF)	Share of intermediate inputs43F [44]	Employment effect in FTE
General hospitals	0.252	0.173	32%	1.4
Ambulant and stationary addiction help institutions	22.233	15.192	32%	122.1
Sum	**22.485**	**15.365**		**123.5**

This chapter covered the available data and estimations for economic effects in the healthcare and treatment segment insofar they are related to recreational cannabis use in Switzerland. The discussion on the quality of the estimation and limitations regarding data availability has shown, that additional research on the topic could further help to improve the estimation once the additional data collection by the FSO/SwissDRG becomes available in the future.

3.10 Police

The previous chapters outlined the data and estimations for the first two segments of the cannabis system, the market as well as healthcare and treatment. This chapter on the other hand covers economic activity by the police forces in Switzerland, which represents the third of five segments.

[44] Federal Statistical Office (2020a).

The police in Switzerland is organised on three levels (Federal Office of Police fedpol, 2021). On the federal level the Federal Office of Police (fedpol) is responsible for international and intercantonal coordination as well as – amongst other tasks – for issues of state security and organised crime. The largest share of operational tasks for on-the-ground police work is organised on the cantonal (state) level. Individual cantons have an additional layer on the city/regional level (e.g., Zurich and Winterthur). For this project I have focused primarily on the cantonal- and city-level, as the activities regarding the enforcement of narcotics law primarily take place on the cantonal-level.

Unfortunately, there is no coherent, national data available in Switzerland on the resources that are used for the enforcement of narcotics law in general, or cannabis-related crimes in particular. Since there is no adequate data for this estimation on the input-side of the police system, I have addressed this issue by trying to estimate the effort from both the input- and output-side.

For the purpose of this project – to quantify the economic resources required annually for police activity related to the enforcement of cannabis-related narcotics law – there are two public data sources available. The first being the crime statistic of the police (Crime statistic of the police, PKS). It collects annual data of all cantonal police forces on the extend and structure of officially recorded crimes as well as data on accused persons, perpetrators and victims (Federal Statistical Office, 2016b). It is important to note, that this statistic provides only crimes recorded with the police forces, it does not show the full extent of crime in Switzerland. The number of crimes recorded in this statistic represent one form of output of the police system, namely recorded crimes which can be persecuted and put to trial in the justice system. However, the statistic does not include input into the system (e.g. budgets, FTE number, etc.) to match with the output.

The second source are the statistics of the federal finance administration (EFV) who provide information of the total amount spend on different public functions by the federal, cantonal, and communal entities in Switzerland (e.g., police, justice, and enforcement). One approach to estimate the economic resources required by the police system would be to calculate average costs per case by using the total amount of reported crimes and the total police budgets (top-down). However, there are several problems associated with this approach. The most crucial one being the assumption, that the effort required per reported crime is equally distributed between different types of crimes, which does not hold up based on our interviews with cantonal police representatives.

I have thus decided on a different (bottom-up) approach to estimate the police resources related to cannabis. The approach consists of four steps. In a first step the quantitative foundation is calculated of the total number of people who were accused of cannabis-related crimes. While this data exists on a cantonal level and is aggregated for the national level, it was not possible to obtain the individual cantonal records. To circumvent this issue, I have approximated the cantonal figures by using the cantonal population numbers as a weight, fully aware that regional differences in cannabis-crime intensity, policing strategy, and resources, etc. cannot be accounted for using this method.

The second step consists of expert interviews with representatives of cantonal police forces responsible for the enforcement of narcotics law in general or cannabis related offences. The field access to the police narcotic experts was facilitated through a letter of recommendation and a personal introduction by the federal office of police, which supported this project by participating in the support group. In total eight cantonal experts were willing to contribute to this project covering about 56% of the Swiss population (Table 15). Most interviews were conducted over the phone with the officer in charge of the narcotics division/dossier in said canton, except for Berne and Zurich. In Berne and Zurich, in-person group interviews at the respective cantonal police headquarter were conducted including again the head of the narcotics division/dossier as well as officers in charge of narcotics investigation and in the case of Zurich a strategic analyst. The protocols of the interviews were reviewed by the participating persons after the interviews to correct any errors or misunderstandings during notetaking.

Table 14: Number of accused people for cannabis-related offences[45]

Type of offence	**Number of accused people**	**Share**
Consumption*	20,201	49.8%
Production*	480	1.2%
Ownership*	10,006	24.7%
Production**	682	1.7%
Ownership**	4,110	10.1%
Trade**	2,980	7.3%
Import, Transit, Export**	1,757	4.3%
Production***	73	0.2%
Ownership***	85	0.2%
Trade***	171	0.4%
Import, Transit, Export***	19	0.0%
Sum	**40,564**	**100%**

* *misdemeanours*

** *minor cases*

*** *major cases*

The interviews (see annex for the interview guideline), amongst other questions, included a bottom-up estimation of the activities and efforts required annually (e.g., by structuring the activities into organisational units and attributing FTE-numbers of the relevant organisational units). However, based on the organisational structure of the cantonal police forces, this is not a trivial task and often required additional research/estimations by the interview-partners. For this reason, this question was, in most cases not

45 (Federal Statistical Office, 2018) aggregate numbers for marijuana and resin related offences. People accused of multiple substances were included by the share of marijuana and resin related offences in comparison to the total number of people accused of delinquencies regarding illegal substances.

answered during the interview, but rather answered post-interview in writing.

Table 15: Expert Interviews with state police officials in charge of narcotic law enforcement

Canton	Population (in m)	Share of pop. CH (in %)
Argovia	0.68	7.9
Basel-City	0.20	2.3
Berne	1.03	12.1
Grisons	0.20	2.3
Lucerne	0.41	4.8
Ticino	0.35	4.1
Valais	0.34	4
Zurich	1.52	17.8
Sum	**4.73**	**55.7**

The third step was cross referencing these bottom-up estimations with the total number of people accused of cannabis-related offences (Table 14) per canton to try to establish a per-person-per-offence estimator per type of offence. This was done either based on actual cantonal figures or based on our approximation, depending on data availability. The estimation was done on a cantonal level first, and the derived first estimator was refined by cross-referencing and verifying it in other cantons in a second refinement. It is important to note, that the interviews with cantonal police forces revealed, that the bandwidth of resources per case is very wide, especially for major cases. It can vary from 10-20 hours to hundreds of hours and months of work for complex cases. The resulting estimator, especially for major cases is thus a crude measure for extrapolating the total effort and should be improved, if more detailed data were to become available in the future.

Table 16: Accused people, estimator, and total effort per type of offence

Type of offence	Number of accused people	Estimator for police effort per accused person in hours	Total estimated effort in hours
Spot fines	6,572	0.75	4,929
Consumption*	20,201	1	20,201
Production*	480	1	480
Ownership*	10,006	1	10,006
Production**	682	27.5	18,752
Ownership**	4,110	27.5	113,027
Trade**	2,980	27.5	81,955
Import, Transit, Export**	1,757	27.5	48,312
Production***	73	55	4,019
Ownership***	85	55	4,673
Trade***	171	55	9,405
Import, Transit, Export***	19	55	1,027
Sum	**40,564**		**311,859**

** Misdemeanours; ** minor cases***, major cases.*

3.10.1 Concluding remarks

Table 16 shows the results of the estimation for the national level. Based on slightly more than 40,000 accused persons for cannabis related offences, I estimate that the total effort required by the police is around 312,000 hours a year which corresponds to about 164 FTE converted by an approximated annual workload of 1,900h. Using a full costing approach (110CHF/h) based on prior research into police cost-structure on the cantonal level these hours were converted into monetary values (see Table 17). Overall, the total costs associated with police activity related to cannabis amounts to 34m CHF annually.

Table 17: Costs for narcotic law enforcement by cantonal police forces in Switzerland

	Total costs (in m CHF)
Labour costs	20.58
Operating expenses	10.29
Investments (depreciation)	3.43
Sum	***34.30***

The economic effects of the police forces are however not isolated to the costs for police activity. On the contrary, the police activity has a direct effect on both market structure and prices. Researchers have worked on the effects of enforcement activity in different illegal drug markets. Caulkins & Reuter (1998, 2010) for example expand the work by (Reuter & Kleiman, 1986) on the effect of risk respectively *enforcement intensity* on prices in drug markets. The result of Reuter and Kleiman's work is, that in drug markets enforcement represents a cost factor similar to compliance costs in legal markets. Based on this assumption they constructed a static equilibrium model with a stable long-term equilibrium, differentiating between heroin, cocaine, and cannabis. They concluded that *enforcement* (especially focused on the production and distribution of drugs) as a policy tool *does partly explain the significant price mark-up* between production and retail price. However, as a tool for the reduction of consumption of drugs, they claim, it has largely been unsuccessful (p. 335).

Caulkins & Reuter (2010) take this initial approach and expand the explanatory power by introducing dynamics from development economics to the model which allow for deviation from the stable equilibrium (for example through external shocks such as product innovation or "new" drugs). They discuss the role of enforcement in contexts when drug markets are neither in a low-use equilibrium (few people using/selling) nor in a high-use equilibrium (widespread use/availability) and conclude that costs and effectiveness of enforcement in drug markets diverges sharply depending on the current structure and trend of the market (pp. 246-248). While the majority of research on the interaction between drug market structure, enforcement as a variable in a regulatory regime and consumption is rooted in the heroin and cocaine markets of the U.S. (and partially of the UK and Australia) the insights and experiences can be adapted to different market circumstances and thus serve as a reference for the cannabis market in Switzerland. These links between police activity and other segments of the cannabis system are discussed in more detail in Chapter 5, which deals with the effects of alternative regulatory approaches.

The topic of this chapter, police activity related to cannabis in Switzerland, represents the groundwork necessary for the follow-up processes in the justice system, which are the subject of the following chapter.

3.11 Justice system

The estimated effort for policing, which was estimated in the previous chapter, builds the foundations for this chapter. Once a person has been charged with a cannabis related offence that exceeds the level of a simple spot fine, the justice system takes over. To estimate the economic effects caused by cannabis related activity in the justice system these processes were distinguished into two different subchapters. The first chapter, representing the fourth segment of the cannabis system, deals with processes and effects happening within jurisprudence and includes costs related to public persecutors, judges, clerks, etc. The second chapter deals with the execution of sentences and includes the quantification of monetary fines, social work and prison sentences. This topic marks the fifth and final segment of the cannabis system as it is structured in this report.

3.11.1 JURISPRUDENCE

Cannabis related offences in Switzerland, that exceed the severity of spot fines, can be punished by fines, social work, monetary penalties, or prison sentences. The task of determining the appropriate punishment rests with the court system in Switzerland which is, generally speaking, organized on two levels. The first instance of courts is organized on the cantonal level where public prosecutors indict the people investigated by the police who are represented by either privately hired legal counsel or public defendants. The second instance of courts are the cantonaly organised "Obergerichte" that serve as an intermediary appellate court. The last instance of courts in Switzerland is the "Bundesgericht" or federal court which is the highest-ranking judicial body in Switzerland and serves as the final appellate court for lower ranking courts.

To determine the economic resources required to execute functions of jurisprudence, data on the amount of court cases as well as relevant cost factors is required. Fischer et al. (2017, pp. 30, 49–52) have summarized some data sources required for the estimation based on an approach covering all illegal drugs:

- Statistic on judicial sentencing (Strafurteilsstatistik (SUS); Federal Statistical Office, n.d.)
- Statistic on youth judicial sentencing (Jugendstrafurteilsstatistik (JUSUS); Federal Statistical Office, 2016c)
- Public spending by public functions (Eidgenössische Finanzverwaltung, 2019)

For the estimation with respect to cannabis, there are two additional data sources, that need to be added.

- Accused people by substance specific offenses (Federal Statistical Office, 2018)
- The share of penal law cases in relation to all law cases on the cantonal level (see Table 21)

The SUS and JUSUS gather demographic data on the people convicted as well as data on the type and extend of penalty issued from the criminal records. It is important to note, that convictions only enter the criminal records once the ruling is legally valid and exceed the threshold of a misdemeanour. This leads to a lag effect in the statistic and revised data for the recent years of the statistic. Especially serious and complex cases can go through multiple levels of appellate procedure and sometimes take some time between a first conviction and the legally valid final ruling. Once the ruling becomes legally valid, it enters the record with the date of the ruling of the first judicial instance. As with other data sources where time series were available, I have used the average data for 2016-2018 to adjust for year-to-year fluctuations. The data was obtained in private communication from the FSO in November of 2019.

Another factor that is necessary for the interpretation of the results is the methodology used to gather this information. Since sentences can contain multiple forms of punishment, the FSO determines a "main" penalty following a hierarchy. The most serious punishment is jail followed by monetary penalties, social work and fines which are on the lowest rank. If someone is sentenced to both a prison sentence as well as a monetary fine, only the prison sentence would be recorded by the FSO which probably underestimates the full extent of sentences slightly. However, there is a major caveat to the SUS and JUSUS data: it only provides data by type of law and not by type of substance.

This means it is only possible to determine the share of people convicted of crimes in relation to narcotics law in comparison to the total number of convicts (6.14% see Table 18) and adjust this for cannabis specific cases later. Most of these cases are treated and decided on the cantonal level. Notwithstanding, the federal court is both the last instance of appellate court for the cantonal courts as well as for the federal penal court responsible for particularly serious crimes involving organized crime, which sometimes can concern narcotic law as well and thus needs to be included. For this reason, Table 18 summarises the share of narcotic law cases treated by the federal court separately in order to derive a relevant cost weight for cannabis related cases.

Table 18: 3-Year averages (2016-2018) of convicted persons by penal law and narcotics law

	Nr. of convicted persons SUS and JUSUS	**Federal court (cases)**
Nr. of people/cases convicted (narcotics law)	6,908	24
Nr. of people/cases convicted (penal law in total)	112,449	7,878
Share of narcotics	6.14%	0.30%

Unfortunately, the SUS, JUSUS and the federal court do not publish data by substances. In order to improve the estimation, it is thus necessary to determine the share of narcotics convicts that are related to cannabis. To approximate this share, data from the PKS was used. The PKS provides data on the number of accused people by type of offense and by substance which allows to determine the share of accused people for cannabis related offenses in comparison to the total share of accused people for narcotics offenses (67%, see Table 19). Nevertheless, since the SUS and JUSUS statistic covers only cases that lead to a criminal record (and thus exceed the threshold of a misdemeanour), a more appropriate share for adjusting cannabis-related case numbers is the weighted average of minor and major cases (56%).

Table 19: Share of persons accused of cannabis-related offenses in comparison to narcotic accusations overall[46]

	Nr. of accused persons	**Nr. of accused people for minor cases**	**Nr. of accused people for major cases**
Marijuana	27,567	6,234	231
Resin	5,494	1,532	41
Cannabis share multiple substances	7,503	1,763	76
Narcotics overall	60,654	13,895	3,753
Share of cannabis	66.9%	68.6%	9.3%

The assumption, that the share of people accused of cannabis related crimes by the police is the same than the share of people convicted of cannabis related crimes is simplified and implies, that all accused persons are actually convicted. There could be reasons, why the share might potentially be lower. A disproportionate number of cannabis related cases could for example be dropped (e.g. due to pettiness or due to insufficient evidence). Based on personal communication with the federal statistical office and the cantonal police forces, the deviation is unlikely to be very big. I therefore decided that the approximation is sufficiently valid to justify using it.

With the quantity of cannabis related court proceeding established, it is necessary to combine this data with the financial side. As pointed out in the introduction to this chapter, there are two different levels in the judicial system, where cannabis related processes occur. The cantonal courts on the one side, and the federal level on the other. The federal finance administration provides accumulated data for all levels of public administration by function,

[46] Federal Statistical Office (2018).

including jurisprudence. The total spending for jurisprudence on municipal and cantonal level is shown in Table 20.

Table 20: Jurisprudence spending municipal/cantonal courts and federal court (in m CHF, 3-year-average 2016-2018)

	Municipal/cantonal**	**Federal**
Wages	1,612*	186
Operating costs	245*	27
Investments	3*	0.59
Total	1,881	214

** The share of wages, operating costs and investments for municipal/cantonal spending is not published. It was derived by assuming equal shares as for the federal level.*
*** The data for the municipal/cantonal level only includes the average of 2016 and 2017. 2018 data was not yet published at the time of calculation.*

Unfortunately, the cost data provided by the federal finance administration does not differentiate between different cost elements. Since the costs cover all forms of jurisprudence including all types of law on the cantonal level, it is necessary to adjust this data to reflect the fact, that the cost weights determined in this chapter apply only to *penal law cases*. Since the cost data entails other law types as well (e.g., family law, administrative law, civil law, etc.) leaving them unadjusted would grossly overestimate the costs. From a cost perspective, I was unable to find a more detailed breakdown of judicial costs in Switzerland by different law-types.

To circumvent the lack of data I instead relied on an approximation using a different data source. Some cantonal judicial directorates publish annual reports that provide data distinguished by different court types. Since these court types are usually organized by different law types, it is possible to discern information on the share of penal law activity in relation to the overall activity of the judiciary. The most comparable indicator across cantons is the number of full-time-equivalents employed in penal law institutions. In order to approximate the share of penal law processes compared to other types of law I have selected a number of cantons, representing about half of the Swiss population, and analysed their annual reports for the share of penal law FTEs in comparison to the total FTE count. The results are shown in Table 21. A population weighted average yields an approximated share of about 11.5%. Again, this approach rests on the assumption that the workload intensity of cases between different law-types is relatively even.

Table 21: Share of penal law FTEs for selected cantons

	Share of penal law FTE	**Population**	**Share of CH**
Argovia	5.5%	678,207	7.9%
Basel-City	10.6%	194,766	2.3%
Berne	12.2%	1,034,977	12.1%
Grisons	13.2%	198,379	2.3%
Lucerne	12.6%	409,557	4.8%
Zurich	13.7%	1,520,968	17.8%
Sum		**4,036,854**	**47.2%**

Applying the approximated cannabis weight to the narcotic case-weight for both court levels, and combining it with the total jurisprudence costs adjusted by the penal law share yields the average cannabis-related costs for jurisprudence in Switzerland (Table 22). The top-down approach used has three major caveats. The first is the assumption that the effort required per case is evenly distributed between different case types. It is almost certain, that this is not the case. For narcotics cases and cannabis cases in particular, the so-called "shortened process" is often applied and has, amongst others, three conditions based on Art. 358 StPO (Fedlex, 2007):

- The accused person needs to apply for the shortened process

- The accused person needs to accept the facts of the accused case at least in a general sense
- The shortened process is not available, when the public prosecutor demands a prison sentence exceeding 5 years

The shortened process does not actually lead to a court proceeding but is handled between the prosecution, defence and accused person. It was, amongst other reasons, introduced to simplify and shorten case complexity (Stadler, 2007, p. 1) and thus is intended to be significantly less work and cost intensive. Assuming that a disproportionately high share of cannabis cases is conducted using the shortened process, this would likely lead to a disproportionately low case cost. However, without further available data on the relation between the different steps in the lifecycle of a cannabis case it is not possible to further specify this estimate. Based on this information, the results ought to be interpreted as an upper threshold with the real costs likely being somewhat lower.

The second caveat is the fact that by estimating average costs on the basis of an output variable of the court system (convictions) leads to the situation, that all costs incurred by public authorities are attributed to convictions, regardless of whether they are specifically case-related. The third caveat of this approximation lies with the costs for court proceedings in Switzerland. If a person is found guilty in penal law proceedings, they have to pay a lump-sum court fee that includes some of the costs the judiciary incurs (Fedlex, 2020a; Justiz Graubünden, 2020). The third caveat is implicitly addressed by the cost-based estimate constructed in this chapter. Since the jurisprudence costs are unadjusted for income, simply disregarding the income side circumvents the issue of potentially double-counting cannabis-related costs.

The first two caveats on the other side are valid critiques of this approach and are factors, how this estimate could be refined in future research. Additional data on cost-weights by case type, or a more refined cost structure that would allow for a bottom-up estimation was not available for this estimation.

Table 22: Total jurisprudence costs for cannabis-related cases municipal, cantonal, federal level (in m CHF)

Wage	8.1
Operating costs	1.3
Investments	0.03
Total	**9.44**

3.11.2 The execution of cannabis related sentences

3.11.2.1 Prison sentences

To estimate the economic effects of the execution of the sentences by the court system, I rely on statistics from the FSO for the different types of penalties issued.

The statistic for the execution of sentences (SVS; Federal Statistical Office, 2016c) provides data on the people entering and leaving the prisons in Switzerland including both demographic data as well as information on the reasons for the sentence. As with other data sources where time series were available, I have used the average data for 2016-2018 to adjust for year-to-year fluctuations. The data was obtained in private communication from the FSO in November of 2019.

Another factor that is necessary for the interpretation of the results is the methodology used to gather this information. Prison sentences can be attributed to multiple offenses against different types of law and with different severity of punishment. The FSO determines a "main" reason following a hierarchy of both severity of the crime and the type of law. A felony exceeds a petty offense which exceeds a misdemeanour, etc. and the same holds true for the hierarchy where the criminal code exceeds narcotics law which exceeds traffic law, etc. In effect this means, that only cases where the offense related to narcotics law is the most severe reason for imprisonment, following the FSO hierarchy, are statistically attributed to narcotics law. This is different to the data provided by the SUS and JUSUS where convictions are entered per type of law regardless of whether they are based exclusively on a particular law type or whether they are a combined sentenced with multiple transgressions against different types of law. In effect this means that the hierarchisation used for the assembling of the statistic probably leads to an underestimation of the true extend of cannabis related offences. Without additional information it is not possible to refine this estimate further.

Table 23: Estimation for narcotic law related prison days in Switzerland (3-year-average 2016-2018) [47]

Average nr. of released inmates from prison	1,097
Average prison day per released inmate	1316
Total number of estimated prison days	343,320

In addition to the estimated number of prison days for cannabis related offences a cost factor for these days was derived using data from the court enforcement concordats (Strafvollzugskonkordat) in Switzerland. The operation and financing of prisons in Switzerland is organized on the cantonal level according to Art. 123 Abs. 2 BV (Schweizerische Eidgenossenschaft, 2021). But because most individual cantons do not have enough delinquents to meaningfully operate individual prisons, the cantons in the 1950s and 1960s decided to organise themselves in three concordats in order to operate prisons on a regional scale (Konkordat der Nordwest- und Innerschweiz, 2020b): one for the eastern part of Switzerland, one for the "latin" part of Switzerland (French and

[47] Data from (Federal Statistical Office, 2016c), received by private communication from FSO. State of the data is from November 2019.

Italian speaking areas) and one for the northern and central part of Switzerland.

Since these concordats are, amongst other things, responsible for organizing the financing of the prison system, they publish cost lists for the various services provided by the prisons within their concordat which are designed to cover about 95% of all costs associated with operating the prisons[48]. These cost lists cover a variety of different services, ranging from half-prison (a form of prison where only nights, free time and weekends are spent in the prison) to maximum security prisons in forensic-psychiatric institutions and differ between different prisons and different concordats. Since no additional data on the exact form of imprisonment of cannabis related inmates is available, I have calculated an average daily rate between "normal" open- and closed forms of imprisonment of 274 CHF per day.[49] Given the wide spectrum of different forms of imprisonment and the costs associated with it, this is obviously a simplification. However, since there is no additional public information available on the structure and form of imprisonment of narcotics law or cannabis related inmates, it is probably the only form of estimation possible without additional primary research on the topic.

Whether the estimated cost rate is accurate or over-/underestimating the true average is hard to validate, as there are arguments for both sides. The department for justice for example estimated an average daily rate (over all prisons and for all forms of imprisonment) of 390 CHF (Eidgenössisches Justiz- und Polizeidepartement, 2013) which is about 42% higher. This was calculated using a top-down approach using overall cost data for the prison system and not bottom up, using daily rates of the concordats and thus probably contains a wider definition of cost-elements than the daily rates. When considering that the average effectively served prison sentence for narcotics law related offenses is less

[48] Private communication with concordat of easter Switzerland.
[49] Based on data from (Konkordat der Nordwest- und Innerschweiz, 2020a; Ostschweizer Strafvollzugskonkordat, 2020).

than a year (see Table 23) and that the threshold for the option of serving half-prison (which is significantly cheaper at around 90-160 CHF) is (amongst other factors) a prison sentence of less than 12 month it might not be unreasonable to assume, that the average rate for narcotics related sentences might be lower than the average rate for all sentences served in Swiss prisons. Without additional data to confirm, this remains a hypothesis, however. For the calculation of the economic effects of cannabis related prison sentences I will use the mean value between the two estimates.

Table 24: Cannabis related costs for prison sentences (3-year-average 2016-2018)

Estimated number of narcotics related prison days	343,320
Average daily cost rate (in CHF)	332
Estimated share cannabis/total narcotics	9.3%
Total estimated cost for cannabis related prison sentences (in m CHF)	**10.56**

Again, we face the same issue as with the calculation of economic effects in the court system: the data is not available on a substance specific level. To address the issue, the share of cannabis cases based on PKS data was approximated. As the PKS releases the number of accused persons both per substance and per category of crime (see Table 19) it is now possible to determine the share of accused persons with cannabis related offences in relation to the total number of people accused of narcotic law related crimes. Nevertheless, the average share of people accused of cannabis related crimes compared to the number of people accused of narcotics laws overall would likely grossly exaggerate the real share. As Table 19 shows, the cannabis share drops significantly when only considering major cases (67% for all cases vs. 9.3% for major cases). Since most minor cases do not lead to prison sentences (even though this is possible following Art. 19 and 20 BetmG (Fedlex, 2011; Zobel, Homberg, et al., 2017a), unless they are repeat offenses, connected to other offences, or fines or penalties are not paid (C. Schneider, personal communication, 7 June 2021), the cannabis share for all cases is likely not a suitable indicator. Because the combined share of minor and major cases would likely severely exaggerate the share of cannabis related prison sentences, I am using instead the share of major cases, acknowledging that this is likely slightly underestimating the true share.

The approximation used for the calculation of cannabis related prison sentences is a simplified estimation based on the available data and the same caveats, as discussed in the previous chapter apply and need to be accounted for when interpreting results.

3.11.2.2 Monetary penalties, social work and fines

In addition to prison sentences there are other forms of punishment which are applied by the judiciary. Monetary penalties, social work, fines and spot fines. The monetary penalties and fines can be taken from the SUS and JUSUS, but again are not available on a substance specific level. They include conditional, partially conditional, and unconditional penalties. The data on spot fines is published by the FSO and is, like the other categories, treated not as a cost factor but rather as governmental income similar to tax revenue. Conditional and partially conditional fines are adjusted by the average share of cases where the condition is broken (Federal Statistical Office, 2016a).[50]

Additional information on the administrative costs of debt collection are not available and are omitted. Applying the same adjustment procedure as for prison sentences and court cases yields the results in Table 25.

[50] The most recent data available is for 2013-2015. However, the share is fairly stable since 2007.

Table 25: Cannabis related monetary penalties and fines (3-year-average 2016-2018)

Monetary penalties for narcotics law (in m CHF)	2.66
Fines for narcotics law (in m CHF)	2.28
Estimated share cannabis/total narcotics	66.88%
Cannabis related spot fines[51]	0.66
Estimated cannabis related monetary penalties and fines (in m CHF)	**3.96**

The statistical number of court mandated cases of social work is rather small. SUS and JUSUS data provide the number of narcotic-law related cases for the years 2016-2018 which are again adjusted for cannabis related cases.

However, it is important to note, that the quantity of social work cases as well as monetary penalties and fines is only a statistical value. These numbers do not represent the actually executed penalties. This is because the SUS and JUSUS only show the number of sentences passed down by the courts and there are cases when the form of sentencing can be changed post-process. For example if a monetary penalty is not paid, it can be converted to a prison sentence (Michael Bühl, personal communication, 24 June 2020). In addition, prison sentences can be converted to social work under certain circumstances (Amt für Justizvollzug und Bewährungshilfe, Staat Freiburg, 2020). This is especially relevant, as there has been a reform of the "Sanktionenrecht" starting in 2018 that has changed social work from being an individual sentence to a court enforcement form. This means, that it is not the courts anymore that mandate social work, but it is the administrative bodies for court enforcement who can decide to do so (Eidgenössisches Justiz- und Polizeidepartement EJPD, 2016). This is also reflected in the data, as the number of statistically captured cases of social work drops to only 8 per year for 2018 from around

[51] Spot fines are based on the 2018/2019 average.

100 in the years before. Since there is no statistical information available on the actual number of executed sentences by type in comparison to the original sentences passed down by the courts, this issue cannot be controlled for without additional research on the cantonal level. According to the interview with Mr. Bühl, the number of cases of social work that were not originally an explicit court sentence is high compared to the total, which is why the statistically low number of social work sentences might be larger at the expense of other sentence types (such as fines and penalties).

Because no cost data for the administration of social work is statistically available, I interviewed an expert on the issue to form a reasonable cost factor per case (Michael Bühl, personal communication, 24 June 2020). This cost factor includes the effort required to place, supervise, and administrate a social work case. The cost factor was estimated bottom-up and thus might not fully capture non-case-related costs in the court enforcement bodies. It was easiest for my interview partner to estimate the effort required in time, rather than money, which is why I have estimated this cost factor as a share of a FTE which is converted into monetary terms using average public administration labour productivity (Federal Statistical Office, 2020a). One aspect, which is not captured in this estimation is the economic value of the social work itself. However, since the case numbers are very low, this is assumed to be of negligible importance.[52]

3.11.2.3 Concluding remarks

While prison sentences are not the only form of punishment passed down by the judiciary for cannabis related offences, they are the largest in terms of economic effects (53%). With costs of about 10.6m CHF they are slightly higher than the second largest category of jurisprudence costs with about 9.4m CHF. Social work

[52] In addition, the value would need to be compared with the costs associated with the organisation of the work mandates by the host institutions.

on the other side of the spectrum appears to be a niche issue with less than 100 cannabis related cases annually and low absolute and per-case costs compared to prison sentences.

Table 26: Estimated costs for cannabis related activities in the justice system (in m CHF, 3-year-average 2016-2018)

Estimated cost jurisprudence	9.44	47%
Estimated costs prison sentences	10.56	52.6%
Estimated costs social work	0.073	0.3%
Total cost justice system[53]	**20.073**	

With respect to the quality of the estimation there are two issues that influence the uncertainty of the results. The first is the fact that most offence-, court- and court-enforcement statistics are not available on a substance specific level. While this is unsurprising when thinking about the data sources and original purpose of the statistics, it causes a significant issue for the purpose of this estimation. The approximation I used by applying the PKS-based ratio of cannabis cases to total narcotic cases alleviates the issue somewhat but has limitations by itself. Given the available information, it is not possible to discern any quantitative indication as to the potential variation caused by this caveat.

The second issue with respect to the quality of the estimation is the difference between sentencing statistics and actual sentences. As explained earlier in the chapter, the statistics on sentences passed down by the courts does not necessarily reflect the actual sentences that are executed. To adequately estimate the actual sentences, it would be necessary to both statistically record the actually executed sentences as well as connect them to the original reason for sentencing (e.g., law-type). While this information is generally available, either on the cantonal level in the

[53] In addition to the costs shown in Table 26 the state generates 4 m CHF income through penalties and fines (see Table 25).

court enforcement administrative bodies or on the federal level at the FSO (Federal Statistical Office, 2020f) it is – to my knowledge – not being statistically connected. This issue does not apply to prison sentences, where effectively served sentences are captured and cross-referenced with the main law-type connected to each sentence and the estimation thus has a relatively speaking higher precision.

The data and discussion on the five segments of the cannabis system that are summarised in chapters 3.1 - 3.4 allow for the estimation of the direct economic effects of these economic activities related to cannabis in Switzerland. However, for understanding the total economic effect it is necessary to also model indirect economic effects triggered throughout the economy by these cannabis-related activities. The following Chapter 4 contains the methodological background for the modelling of these indirect effects in the context of this project and presents the results obtained from the IO-Model.

CHAPTER 4: ESTIMATING INDIRECT EFFECTS OF THE CANNABIS SYSTEM

From an economic point of view the economic cannabis system is a cross-cutting sector, that includes a variety of heterogeneous activities and actors, i.e. consumers, producers, importers, wholesale and retail trade, the criminal justice system, police, the healthcare sector, social workers, etc. Chapter 3 outlined the initial economic impulse, that this cross-cutting cannabis system generates annually in Switzerland. It includes economic activity on different levels (consumers, producers, public authorities, etc.) and in different forms (e.g. costs, expenditures, revenue, taxes, wages, or profits.). These economic effects are the result of both the populations consumption preferences and the current form of regulation applied in Switzerland, amongst other factors. Nevertheless, the effects estimated in Chapter 3 only represent a part of the economic activity in Switzerland that is caused by the cannabis system, the direct economic effects.

These direct effects in return, cause additional economic effects through so-called economic multiplier effects (Miller & Blair, 2009, p. 258; Raa, 2006, pp. 25–30). Generally, I distinguish three different effects for this analysis: the intermediary input effect, the income effect, and the investment effect. Some authors call these effects indirect and/or induced effects (see Demski (2020) for US-based IO Models).

The intermediary input effect captures activity caused by the necessity for intermediate inputs (such as raw materials, energy, services, etc.) that firms require to produce their respective outputs. The firms providing these intermediaries inputs require intermediary inputs in return. By this process, the final demand caused by the cannabis system triggers a wide array of economic effects throughout the economy by individual firms across the supply chains.

Firms need more than intermediary inputs though, to produce output. Investment goods are a necessary ingredient, since producing output depreciates the capital stock which needs replacement from time to time. Additionally, market dynamics and growth can lead to the expansion of the capital stock over time. Producing these capital goods again triggers activity across supply chains, since the firms producing these goods are stimulated by the initial impulse. Both the production of investment goods as well as the supply chain effects triggered by this activity are captured in the investment effect. However, since investments play a very minor role in the cannabis system, at least on a direct level, (see Chapter 3) I have decided not to calculate this particular effect.

The third effect, that is indirectly triggered by the initial impulse is the income effect. This effect captures economic activity, that is triggered by the additional labour income generated by the cannabis system itself (e.g. producers, doctors, judges, police officers) as well as by the labour income across the supply chain. The wages generated by the economic activity in the cannabis system are mostly (adjusted for taxes and the saving rate) spend on goods and services (e.g. food, rent) which in turn trigger economic activity in the Swiss economy. Calculating this income effect needs to account for the fact that a share of the generated income is not spent by the receiving households but is redistributed and spent by other households through the social transfer system (e.g. unemployment insurance).

Adding these various effects up yields the total economic activity in the Swiss economy that is connected to the initial economic impulse of the cannabis system. This in return does not mean, that all these effects would not occur if cannabis would not exist. This would only be the case, if all economic activity estimated in the cannabis system would cease to happen without any form of substitution. A much more likely scenario, given the resource utilization in Switzerland (e.g. low unemployment rate) is that the activity would shift to other causes. Doctors could be treating other patients, producers could grow other crops instead or work in alternative jobs and consumers could instead buy alcohol, other illegal substances or spend their money elsewhere.

What the estimation of indirect effects allows is thus less to infer causality (because of the economic effects of cannabis system x happens) but rather infer contribution (the cannabis system sustains x economic effects in the Swiss economy). It additionally enables the analysis of changes in consumption patterns (e.g. with respect to different forms of regulation), in production patterns (e.g. substitution effects between imports and domestic production) and in links between industries (e.g. sale in dispensaries vs. kiosks).

There are additional features that can be incorporated in the IO-model for future research such as the estimation and integration of cannabis production and/or trade as a separate industry or budgetary substitution effects of household consumption changes caused by price changes of cannabis. It would also be possible to extend the model vertically. Either by expanding it upwards (including other countries) or downwards (including the cantonal level). This would allow the simulation of changes in the supply chain including the imports or analyse specific regional and interregional effects of production, trade, and consumption on a cantonal level. Especially the latter could be interesting, in the case of cantonaly different regulations in the future.

4.1 METHODOLOGY AND DATA OF THE IO-MODEL

The calculation of the cannabis systems indirect effects is being done by an adapted model that is based on the impact_CH model initially developed by Rütter+Partner.[54]

It is based on the Swiss input-output table that quantitatively depicts the flow of goods and services between industries and from industries to final demand (household and government consumption, capital formation and exports) as well as industries' primary inputs with a high level of sectorial disaggregation.

Since the calculation of the indirect effects requires the analysis of the entire supply chains it is based on the most up to date (2014) input-output-table (IOT) available for Switzerland[55]. The general concept of input-output analysis is well developed and has been applied for decades for a variety of research approaches (Eurostat, 2008; Leontief, 1986; Miller & Blair, 2009; Raa, 2006; UN Statistics Division, 1999). A compact introduction is provided by the United Nations department of economic and social affairs statistics division (2018, pp. 603–641).

The IOT provides the industry links for the 52 industries in the Swiss economy, GO and GVA on the industry level as well as the supply for the final demand. It additionally provides data on the consumption structure for goods of services of private households for the estimation of the income effect. Additionally, the model incorporates the following data:

- Employment by industry, derived from the structural business statistics and the labour productivity statistics. This data

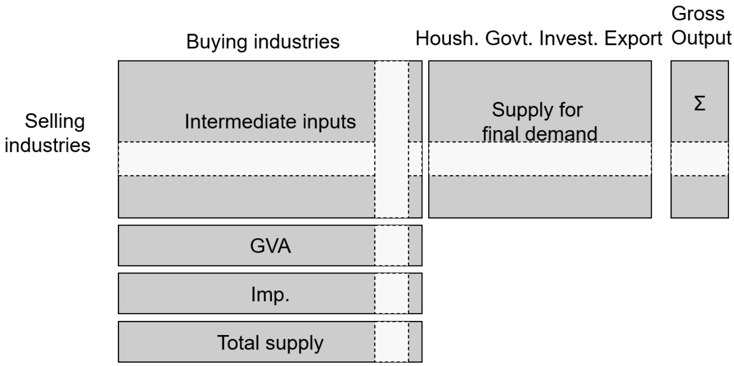
[54] Tonio Schwehr and Carsten Nathani provided valuable assistance in the compilation of chapters 4 and 5. Both in the configuration and adaption of the model as well as in providing feedback in the interpretation of the results.
[55] Due to the slow change in the economic structure and the large effort for compiling IOTs, the national IOT for Switzerland is published in irregular intervals. The previous IOT was based on 2011 data, the most up-to-date table at the time of calculation is for 2014.

allows for the calculation of industry specific labour productivity by dividing gross value added by employment.

- Employment by industry and firm size, also based on the structural business statistics.
- Share of cross-border commuters in employment, based on the cross-border commuter statistics
- Gross wages of employees by industry, based on data from the Swiss labour cost statistics, the work volume statistics and the structural business statistics and aligned to data from the Swiss national accounts. The data used for the model is from 2016.
- Data on the savings rate of private households and social insurance contributions and benefits from the national accounts (Federal Statistical Office, 2020b).
- Data on income tax of private households from the Swiss income tax statistics
- Data on depreciations of capital stocks by industries which can be used for the calculation of the investment effect. This data is based on the Swiss national accounts and data from the German input-output tables. However, for this estimation the calculation of the investment effect was left out due to the negligible importance of investments in the cannabis system.

Country and industry specific data on the supply chain structure of agricultural products similar to cannabis for domestic production (Nathani et al. 2016)

Figure 10: Schematic layout of an input-output-table



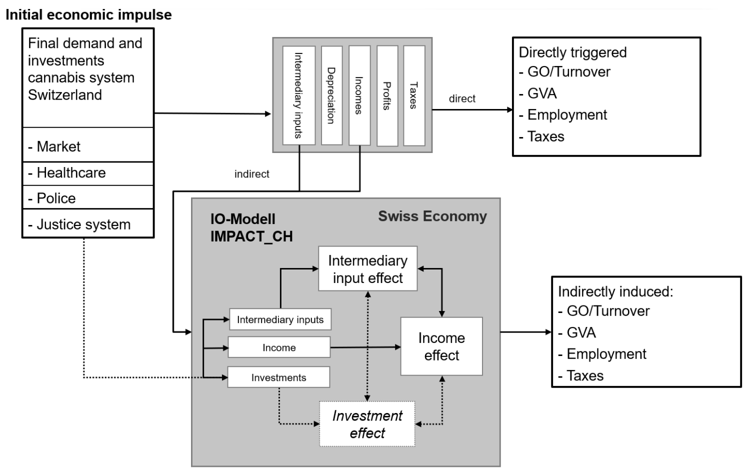
4.1.1 INPUT-OUTPUT MODEL

Figure 12 provides a stylized overview of the IO model used for the calculation of the direct and indirect effects of the cannabis system. In a first step the estimated final demand of the cannabis system (see Chapter 3) is broken down into the respective economic components and constitutes the direct economic effects of the cannabis system. The input for the IO model was constructed differently for two groups. The market, police and jurisprudence impulses were constructed by estimating the direct effects with respect to gross output, gross value added and FTEs. The estimated intermediate inputs on the other hand are broken down into selling industries insofar information on the structure of the intermediate inputs could be derived meaningfully (see Nathani et al. (2017) for the disaggregation for agricultural goods). In addition, if the initial impulse constitutes an illegal activity – as it is the case for market activity – VAT is being deducted on intermediate inputs. This is because due to the illegality of their economic activity, the actors in the market cannot deduct input taxes.

The adjusted intermediate inputs are then used as an input for the IO model and the indirect effects are calculated (see description below). All resulting effects (IE and IIE) are considered indirect effects. In addition, the initially estimated direct wages are also used as an input for the IO model to calculate the indirect effects triggered by the respective consumption expenditure. If these wages are legal, they are previously adjusted for social security payments.

For both the jurisprudence as well as for the healthcare segment the method had to be slightly adapted, as there was not enough data available to distinguish intermediate inputs by selling industries. As it was only possible to estimate costs associated with these segments, but not possible to determine the exact cost structure, the total costs for these industries are used as an impulse for the respective industries: NOGA 84 public administration and NOGA 86 healthcare. The breakdown of the costs into intermediate inputs, GVA, etc. is thus determined by industry averages according to IOT data. The first stage of the calculation cycle constitutes direct effects, whereas subsequent stages are considered indirect.

Figure 11: Schematic overview of the IO-Model



The various effects are calculated using the following matrix and vector equations:

$$Intermediary\ input\ effect = (\widehat{1-m}) \times ((I-A)^{-1} \times F) \qquad Eq.\ 6$$

For the intermediary input effect, $(I\text{-}A)^{-1}$ stands for the Leontief inverse matrix which holds the economic multipliers that represent the effects on successive industries for any change in final demand. I is the identity matrix and A the intermediate input coefficient matrix, that is calculated by dividing intermediate inputs of the IOT column wise by total product supply. Total supply is the sum of gross output and imports.

F on the other hand is a vector representing the intermediate inputs by each segment of the cannabis system by selling industries. Combining both yields the additional indirect effects along the supply chains for the initial impulse by industry.

Multiplying the Leontief inverse with F yields total product supply. To deduct imports the results is multiplied with a diagonal matrix $(\widehat{1-m})$ representing the domestic share by product group.

$$CE = \frac{E \times (1-b) \times GW \times (1-sc-it-s)}{(1+npt_h)} \times G \qquad Eq.\ 7$$

Consumption expenditure CE is calculated with E representing the calculated employment effect, b the share of cross-border commuters in the domestic workforce, GW the gross wages, sc the rate employee´s share of social security, it the average income taxrate and s the savings rate. In the denominator npt is the average net product tax share of household consumption including VAT. Multiplying this with G (the structure of goods related to CE according to the IOT) provides us with consumption expenditure by goods.

$$Income\ effect = (\widehat{1-m}) \times (I-A)^{-1} \times CE \qquad Eq.\ 8$$

The income effect triggered by the wages generated in the cannabis system is calculated by *Eq. 8* with CE being the consumption expenditures triggered by wages within the cannabis system and across supply chain industries again corrected for imports.

$$NPT\ on\ Consumption = CE \times npt_h \qquad Eq.\ 9$$

The net product taxes (including VAT) on consumption expenditure is calculated by multiplying consumption expenditure (CE) by the average product tax share of household consumption (adjusted for subsidies) at cost price (npt_h) based on IOT data.

$$Income\ taxes = \sum_{i=1}^{N} E_i \times GW_i \times it_i \qquad Eq.\ 10$$

The total income tax is calculated by multiplying gross wages (GW) per industry by the employment effect in FTE and by the average income tax rate (it) per industry based on data from the Swiss Federal Tax Administration.

$$Taxes\ on\ products\ (net\ subsidies) = \sum_{i=1}^{N} GO_i \times npt_i \qquad Eq.\ 11$$

The net taxes on products are calculated by multiplying gross output (GO) per industry by the average product tax rate (pt) per industry based on IOT data reduced by subsidies per industry, yielding the average net product tax rate (npt).

$$Employment\ effect = \sum_{i=1}^{N} \frac{VA_i}{LP_i} \qquad Eq.\ 12$$

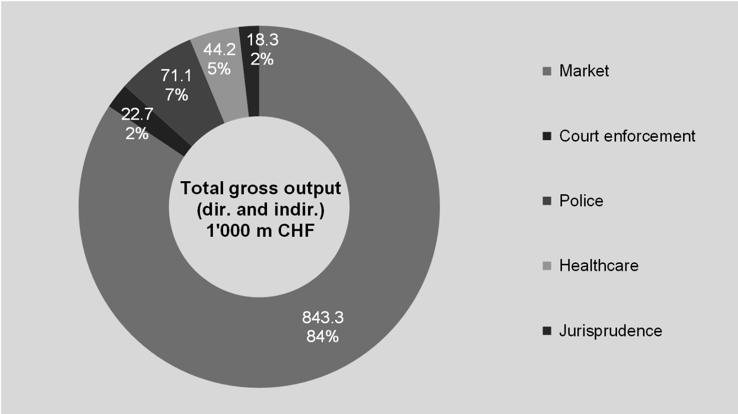
The employment effect is calculated by dividing value added (VA) per industry by labour productivity (LP) per industry. The value added is calculated by multiplying the sum of the direct effect, the intermediate input effect and the income effect by industry with the industry specific value added share of gross output.

The sum of Eq. 6 and Eq. 8 constitutes the total of indirect effects for the cannabis system as well as the tax revenue generated from the economic activity. The sum of direct and indirect effects is shown in chapter 4.2.

4.2 Results

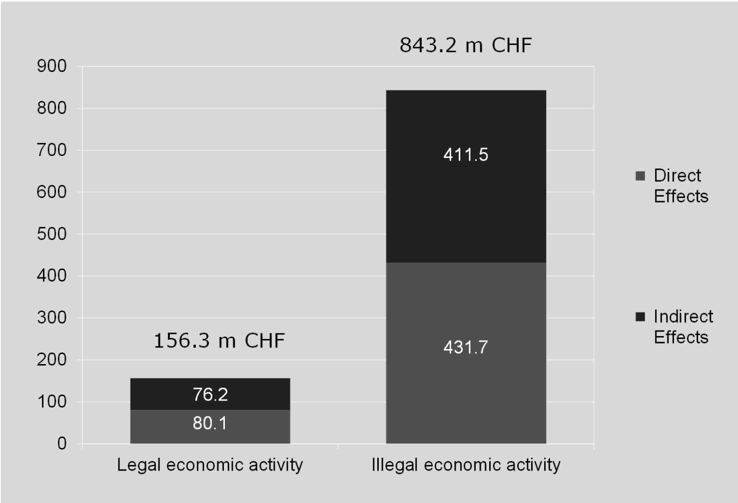
Applying the methodology outlined in chapter 4.1 yields the total (direct and indirect) economic effects associated with the cannabis system in Switzerland. Overall, the economic activity associated with recreational cannabis in Switzerland generates total gross output of around 1b CHF annually. The by far largest share of this activity is triggered by the market processes of production, import, wholesale, and retail-trade (84%). The other segments of the cannabis system make up the remaining 16% with police activity being the largest individual share (7%). When comparing the dimensions of the non-market segments of the cannabis system the results show that there is a ratio of about 1:5. For each Swiss Franc linked to activity in non-market segments, 5.3 of revenue is linked to market activity.

Figure 12: Breakdown of total gross output (dir. and indirect)



The results in Figure 13 can also be interpreted from a different perspective. When considering which of the economic activity is legal and which is illegal under the current regulation, the results shown in Figure 14 are striking. The breakdown of total gross output shows two different categories: legal and illegal economic activity.

Figure 13: Breakdown of total gross output into legal and illegal economic activity



For the interpretation of the results there are two different ways of thinking about the question of legality. The first is a narrow definition, which only considers economic activity that by itself is illegal. If a dealer for example sells Cannabis for 100 CHF, this transaction, this direct economic activity is illegal. If he spends the 100 CHF he made for the purchase of soil, food and electricity, the purchases of these goods are per se not illegal but are funded by monetary means obtained from illegal activity. This is the wider definition of illegality. In the narrow definition, about 432m CHF of gross output (43% of the cannabis system) are linked to direct effects caused by illegal activity. The wider definition, including indirect economic effects triggered by initially illegal economic activity comprises a total of 843m CHF or 84% of total gross output of the cannabis system.

Figure 14: Breakdown of the intermediate input effect (IIE)

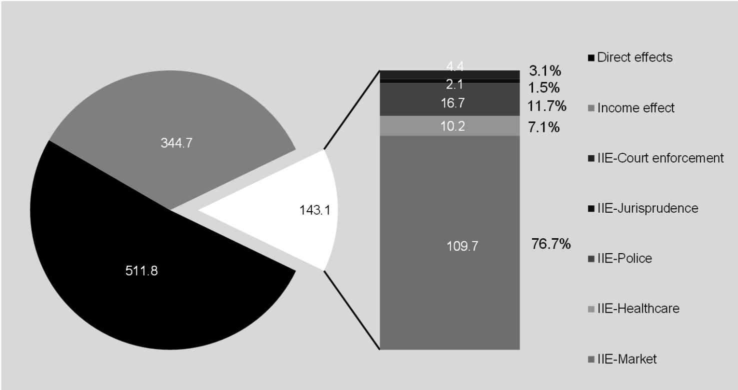
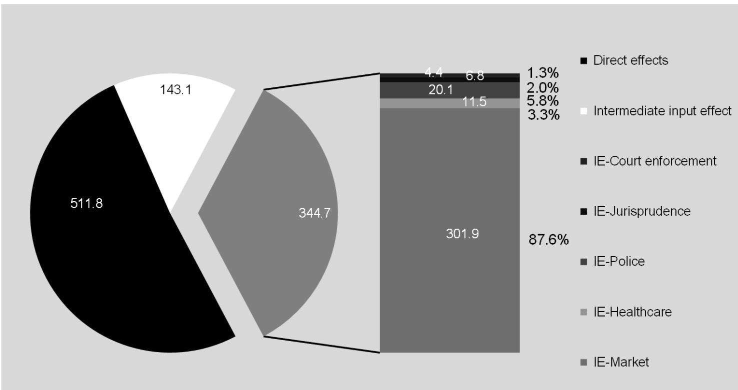


Figure 15: Breakdown of the income effect (IE)



Another interesting aspect of the results is shown in Figure 15 and Figure 16 that show the individual components of both the intermediate input effect (IIE) and the income effect (IE). The share of the market segment of the cannabis system is disproportionally higher for the IE (87.6%) as for the IIE (76.7%). This is caused by the fact that the relative share of income generated in the market segment compared to intermediate inputs is significantly higher for market activity as it is for non-market activity (see Figure 10)

Table 27: Direct and indirect economic effects of the cannabis system in Switzerland

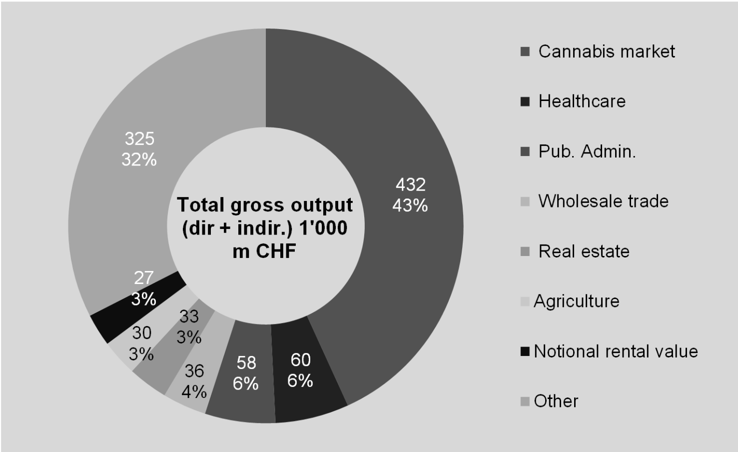
	Gross Output in m CHF	Gross value added in m CHF	Employment in FTE[1]
Direct effects	**511.8**	**428.0**	**2,686**
Court enforcement	13.9	10.7	37
Jurisprudence	9.4	8.1	41
Police	34.3	24.0	164
Healthcare	22.5	15.4	124
Market	431.7	369.8	2,320
Indirect effects	**487.8**	**244.8**	**1,759**
Income effect	344.7	184.3	1,193
Court enforcement	*4.4*	*2.4*	*15*
Jurisprudence	*6.8*	*3.6*	*23*
Police	*20.1*	*10.7*	*70*
Healthcare	*11.5*	*6.1*	*40*
Market	*301.9*	*161.5*	*1,045*
Intermediate input effect	143.1	60.5	566
Court enforcement	*4.4*	*2.1*	*14*
Jurisprudence	*2.1*	*1.0*	*7*
Police	*16.7*	*7.7*	*54*
Healthcare	*10.2*	*4.3*	*24*
Market	*109.7*	*45.4*	*467*
Total effects dir. + indir.	**1,000**	**672.8**	**4,445**
Court enforcement	23	15.2	66
Jurisprudence	18	12.7	71
Police	71	42.4	288
Healthcare	44	25.8	188
Market	843	576.7	3,832
Taxes, penalties and fines	**25.4**		
Court enforcement	1.07		
Jurisprudence	1.21		
Police	4.26		
Healthcare	2.01		
Market	12.89		
Penalties and fines	3.96		

1) Full time equivalents

Table 27 shows the details of our estimation along three different variables. Gross output, which can be interpreted as revenue for most industries, gross value added which corresponds to GO less intermediate inputs and is the share of economic activity that contributes to GDP (on the direct level), and employment in full time equivalents (FTE). In addition, Table 27 shows the total tax effects triggered by the economic activity which includes income taxes, VAT and other product taxes such as fuel taxes. It is important to note, that the employment effect does not correspond to an actual number of people employed in each segment of the cannabis system. It is a measure of work volume and corresponds to the average annual workload of a full time employed person. It is calculated using industry specific labour productivities.

The most aggregated variable is total gross output triggered by economic activity related to recreational cannabis usage in Switzerland. This amounts to about 1b CHF annually including both direct and indirect effects and all segments of the cannabis system. Figure 17 breaks down total gross output by industries. Next to the direct effect triggered by the market itself, other large industries affected by the economic activity in the cannabis system on both the direct and indirect level include healthcare (60m), public administration (58m) and wholesale trade (36m). Real estate (33m) and the notional rental value (27m) are also affected by both expenditure on rent and ownership. The total gross output for the agricultural sector in Switzerland in the status quo amounts to 30m. 325m CHF are triggered in other industries in the Swiss economy by the interconnectedness of the Swiss economy.

Figure 16: Total gross output of the cannabis system by industries (in m CHF)



Value added, which represents gross output less intermediate inputs is a different perspective on the economic effects because it includes primarily labour and capital used for producing the gross output rather than including intermediate inputs. When only considering value added, the total effects amount to about 672m CHF annually of which 428m CHF are triggered on the direct and 245m CHF on the indirect level. The directly generated value is the most appropriate variable for comparison with GDP data, which for 2017 amounted to 693.7b CHF (Federal Statistical Office, 2021a). The direct value added generated by the cannabis system roughly corresponds to about 0.06% of Swiss GDP or to about half of the economy of the canton of Appenzell Innerrhoden. The closest industries in Switzerland with a similar size are water supply (NOGA 36) which is slightly smaller at 0.04% or the production of cars and car parts (NOGA 29) which is slightly larger at 0.08% (Federal Statistical Office, 2020e, 2021b).

The total employment effect of the economic activity associated with the cannabis system amounts to about 4,400 FTEs. As a point of reference this is slightly more than the employment generated by the Swiss accident insurance (SUVA), which employs about 4,200 employees in Switzerland (Schweizerische Unfallversicherung Suva, 2021) and slightly less than the number of leadership positions at the city of Zurich (4,525; Stadt Zürich, 2020).

The overall tax revenue associated with the economic activity triggered by the cannabis system amounts to about 25m CHF annually. This includes income taxes, VAT and other product specific taxes such as fuel tax. There are two things to consider when interpreting this value. The first is the fact that a significant share of value added (which includes wages) on the direct level are illegal incomes and are thus simulated to neither include social security payments nor income taxes. The same applies to VAT which is only calculated for the legal segments of the cannabis system as well as for indirect effects. The second is the fact that the calculation of the status quo does not include any specific form of taxation for cannabis. In effect, the form of taxation for the status quo is similar to the Free-Market scenario, with the exception, that market activity is assumed to be legal and VAT taxed in the latter.

4.2.1 Comparison to other analysis

While there are similar studies dealing with the analysis of individual segments of the cannabis system, most either use a different methodology (social costs, cost-benefits, etc.) and are thus incomparable or deal with a different subject (e.g. drugs in general). At the time of writing, research on the subject did not reveal any similar approach covering a comprehensive analysis of a national cannabis system with a methodology conforming to national accounting standards. The following paragraphs cover additional research which connects to the results of this project, starting with research in Switzerland, even if there are limitations with respect to comparison.

There are several studies which have been conducted worldwide taking a social costs account to either illegal drugs in general, or cannabis in particular. For Switzerland, "*The costs of illegal drug* *consumption in Switzerland"* (for all relevant illegal drugs) is the topic of a study by Danthine & Balletto (1990) who calculated a value of about 290m CHF (average between a minimal and maximal scenario) for the costs of consumption and about 175m CHF for the enforcement costs. These results were evaluated and enhanced by a subsequent approach from the viewpoint of normative economic theory by Bernasconi (1993). He concludes that external effects and asymmetric information with respect to health-consequences and product quality justify governmental intervention in the illegal drug market (p. 12). Concerning the monetary costs of illegal drug consumption in 1990 he calculates a value of 484m CHF (p. 70), about 67% more than Danthine and Balletto. For the regulatory costs, the enforcement costs of the regulatory regime in 1990, he calculates a value of 311m CHF (p. 70) based on available statistics at the time. Concerning non-monetary costs (mortality and morbidity costs) he estimates a value of 132m – 4.424m CHF (p. 70) depending on the estimation factors. Both studies deal with the market for *all illegal drugs in Switzerland* and even though they include cannabis, they do not differentiate between different classes of drugs. Additionally, both studies work with a *normative "cost" definition* based in a public-costs and harm-done view of drug consumption. While this view has its merits if arguing from a public-policy/cost-benefit direction, it has limitations with respect to the analysis of the scope of the cannabis system as a whole as well as to the evaluation of policy effects of regulatory alternatives to the economic cannabis system.

A different approach to a cost analysis of illegal drugs was used by Jeanrenaud et al. (2005). While also using a cost-based approach, they used the concept of *social costs*. Since these costs are partially incurred today and partially in the future, this approach calculated all contemporary and discounted future costs caused by consumption today and in the past (p. 7-8). They separated between direct costs (such as enforcement or overdose treatment), indirect costs[56] (such as productivity loss or premature morbidity/mortality) and human costs (such as deteriorating life quality of users and connected persons). For Switzerland in the year 2000 he calculated total social costs of 21.5b CHF for alcohol, tobacco and illegal drugs together. This corresponded to roughly 5% of the Swiss GDP. Illegal drugs (including cannabis) make up 4.1b CHF (1.2% of GDP). The most recent analysis of social costs for addiction overall was conducted by Fischer, Mäder, et al. (2020) using the cost-of-illness methodology. For 2017 they estimate the social costs of addiction at around 7.7b CHF. The largest contributors being tobacco (3.9b CHF) and alcohol (2.8b CHF). Illegal drugs account to 922m CHF of social costs according to their estimate. The cost estimate for illegal drugs consists of healthcare costs of about 274m CHF and 467m CHF in the criminal justice system. The remaining 181m are indirect costs associated with productivity losses. While they calculate a share of GDP for illegal Drugs (0.02%), it is unclear whether this is related to the actual costs, only the direct components and/or the value-added associated with these costs. The interested reader finds a comprehensive overview of social cost estimates for countries in the European Union in Barrio et al. (2017). Given the extraordinary wide ranges of results and estimations they conclude "*there is an urgent need for methodological guidance, a need to standardise and homogenise the methodologies employed for social costs evaluations*" (ibid. p. 586).

Zobel et al. (2020) have conducted a research project neither using social costs nor cost-benefit-analysis (CBA) but instead focusing on quantifying the economic size of the cannabis market in the canton of Vaud. Contrary to the previously mentioned research projects they thus specifically include private "costs" to the analysis and use primarily bottom-up estimation methods using available domestic data from surveys and other sources. Since this project provides the methodological footing for our national estimate of the cannabis market segment (see chapter Chapter 3) the

[56] It is important to note, that the definition of "indirect" is different in the social cost methodology than it is in the analysis conducted in this project (see chapter 5.1).

results are comparable with some limitations. The authors estimate a consumption amount of about 3.5t-5.1t of cannabis (marijuana and resin) resulting in a revenue of 31.7m-46.3m CHF including a maximum profit of 20.6m-30.4m CHF. They also extrapolated their findings for the national level and estimate the total revenue around 340m-500m CHF including a maximum profit of 220m-325m CHF which is slightly lower than our estimate of 580m CHF direct revenue. A similar approach for the estimation of cannabis markets was conducted by Haucap et al. (2018) who estimate a cannabis market demand of about 250t for Germany. The same project also calculates the net effect on public finances in the case of a legalisation and estimates a value of 2.7b Euro (ibid. p. 56) of which about 1.6b are taxes and the remainder are costs saved by police forces. Cost savings in the criminal justice system were not estimated. While this project primarily deals with the market segment of cannabis in Germany, Effertz et al. (2016) estimate causal healthcare costs associated with cannabis use of about 975m Euro based on health insurance information. For the Netherlands, where a particular form of retail regulation is applied, van der Giessen et al. (2016) estimate a consumption quantity of 32t-49t (excluding non-residents) with an export estimation of between 53t-937t, underscoring the Dutch role in the supply for the European Market.

Other estimates on the market size of cannabis include Colorado, where recreational cannabis possession, consumption and trade was legalised in 2012 and 2014 respectively. Light et al. (2014) estimate market demand at about 121t in 2014, which is approximately 23g per capita compared to around 7g per capita in our estimation. Kilmer, Sohler Everingham, et al. (2014) on the other hand focus their analysis on the entire U.S. market for illegal drugs and estimate a cannabis market at about 40.6b USD for 2010. However, given the various regulatory changes in the U.S. since the release of this report, this value has probably changed. Werb et al. (2012) estimated retail value for the cannabis market adjusted for under-reporting in British Columbia in Canada and conclude a value of 443m-564m CAD (~330m-420m CHF). For the European context the European Monitoring Centre for Drugs and Drug Addiction & Europol (2019) provide the most recent estimate for the cannabis market in the EU (11.6b Euro).

There are other methods, that can be applied when analysing illegal drug markets and/or their respective regulation. van Dijk (1998) touches the problem of one-dimensionality in the analysis of cannabis policy and attempts an interdisciplinary approach. His conclusion lists both the pros and cons, albeit they remain unweighted by the author. Concerning the effects of the regulatory regime he concludes that while

> "The Dutch drug policy, measured against its own objectives, is therefore a moderate success", the regulation regime "is not advantageous to the government in financial terms" and that "against the relatively high expenditure for care there is no lower expenditure for the criminal justice system. The tax income from the tolerated cannabis sales is probably of a minor order." He states: "In a traditional cost-benefit analysis the anticipated effects are assessed in financial terms. This is only possible to a very limited extent when it comes to the drug policy" (p. 383).

A seminal paper by Miron and Zwiebel (1995) on the economic case against drug prohibition outlines a framework for the normative evaluation of drug policy from an economic perspective. They compare the US regulatory system for illegal drugs to a counterfactual legal scenario, where drugs are a "normal" consumer good and include aspects of the system in places such as violence, crime, enforcement, abuse of market power (e.g. cartelization) and externalities associated with drug use. Based on their analysis of the status quo in the US, their evaluation of other approaches such as the Dutch (harm reduction), the British (medicalization) or alcohol/tobacco they conclude (p. 190):

> "[…] our conclusion is that a free market in drugs is likely to be a far superior policy to current policies of drug prohibition. […] existing evidence suggests the social costs of drug prohibition are vastly greater than its benefits."

Dealing with another question within the topic of drug regulation, Miron (2010) calculated the budgetary costs of the prohibition regime in the U.S. and concluded that the regulatory regime for all illegal drugs at the time (1990) incurred annual costs of about 50b USD governmental expenditure of which about 2/3 was paid for by state and local governments. Differentiating by individual drugs he calculated governmental costs of about 13.7b USD for cannabis alone (p. 3). Jacobi & Sovinsky (2016) developed a buyer behaviour model to analyse the effect of decriminalisation and legalisation of cannabis usage. They explicitly integrated variables of accessibility as well as the (dis)utility of illegal action. Applying this model to data from the Australian National Drug Household Survey they find that (a) both accessibility and illegality play a role in the consumer decision to use cannabis and (b) that the effects are different for different age groups. Concerning the question of tax revenues[57] they conclude:

> "in the worst case tax revenue scenario - all current users purchase on the black market - legalization in Australia (or the US) would still result in tax revenues of $61 million (over $700 million) annually. At the other extreme, the government would raise almost a billion ($12 billion) in taxes". (Ibid., p. 30)

A finding generally in line with other results on the topic such as Miron (2005, p. 30).

As shown, the state of research on the analysis of cannabis regulation regimes has multiple methodological approaches. The first is a cost-benefit approach to cannabis regulation. The second is based on a social costs/cost-of-illness approach taking indirect and intangible costs into account as well and omitting the private/individual side of costs. While both these approaches have their own merits: one focusing on the perspective of the regulatory

[57] Calculated using the midpoint in reported usage intervals. The lower boundary corresponds to a taxation at current cigarette taxation (marginal costs + tax) whereas the upper boundary corresponds to current illegal market price + 25% (a proposal in the U.S. at the time of release of the paper).

actor, the other on the perspective of society as a whole, neither of these approaches gives a comprehensive picture of the *economic dimension of the cannabis system overall.* On the one side because important economic activities are left out by including only selective activities (such as public costs) and on the other, because focusing solely on the costs leaves out several other important aspects such as generated output, tax income or employment effects. Unless all economic activity across the entire supply chain connected to cannabis are considered any analysis of the economic cannabis system will remain partial. In this project, I have tried to address this issue by focusing on all economic activity related to the cannabis system.

Chapter 4 presented the methodology used for the calculation of the indirect economic effects triggered by activity in the cannabis system using an Input-Output-Model based on the Swiss economy as well as the results from the estimation. In combination with the direct economic effects which were described and quantified in Chapter 3 the overall economic effects constitute the total economic effect associated with the current form of regulation of cannabis in Switzerland. These results now allow for the comparison of economic effects to alternate forms of cannabis regulation. Chapter 5 will discuss the economic working mechanisms of different regulatory approaches and simulate the economic effects associated with three stylized forms of regulation.

Chapter 5: Economic effects of different forms of cannabis regulation

The estimation of the economic effects associated with the current form of cannabis regulation in Switzerland in Chapter 3 and Chapter 4 leads to the obvious follow-up question of how the economic effects would change if a different form of regulation were to be applied.

This question, however, is complex because the regulation of cannabis has an immense width. It is not a binary choice between total prohibition and full legalization. In fact, there is a very wide spectrum of regulatory approaches that settle in between these two extremes. Broadly speaking, the spectrum of cannabis regulation (as with other substances), from an economic point of view, is a continuum between complete prohibition with severe punishments and strict enforcement to a largely unregulated, market-based, for-profit model (Figure 18). It is a continuum, because there is a quasi-infinite combination of specific regulatory variables, that can shift any specific regulatory scenario along the spectrum. Considering this situation, it is necessary to reign in the complexity of cannabis regulation to create a baseline, that allows for meaningful simulation and analysis of regulatory scenarios.[58]

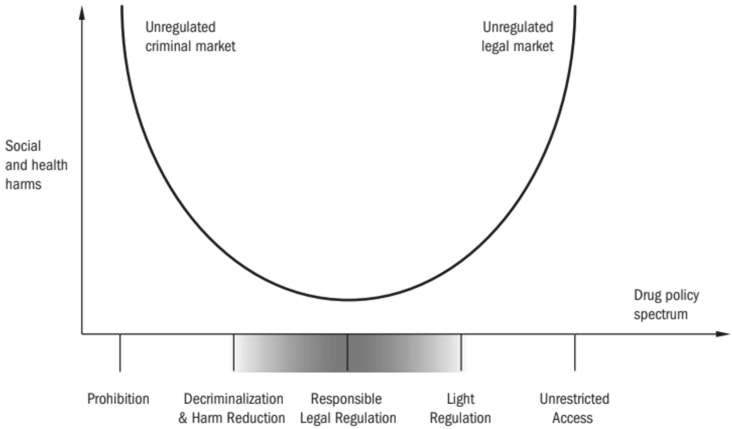
With major changes in cannabis regulation happening across the globe only very recently, the evidence on the effects of different forms of regulation is starting to grow. However, at this stage

[58] Some of the most condensed work on this issue are the books "Marijuana legalization" by . J. P. Caulkins et al. (2016), "Legalizing Cannabis: Experiences, Lessons and Scenarios" by Decorte et al. (2020) and "How to Regulate Cannabis" by Rolles & Murkin (2013).

there is simply not enough information available to accurately predict the effects of complex forms of regulation. This is especially true, because the effects of different forms of regulation are not necessarily transferable from one jurisdiction to another (Pacula & Sevigny, 2014). The aim of this chapter is thus not to discuss the various areas of cannabis regulation in great depth. This has been done extensively by other researchers. The intent of the project is neither to create detailed regulatory scenarios including provisions for specific aspects of cannabis regulation such as production standards or THC thresholds, etc.

The aim is instead, to use a set of stylized regulatory scenarios which exemplify different forms of supply- and demand-side regulation. By doing so it is possible to simulate shifts in the cannabis supply chain and in market demand as well as provide some insight into the quantitative effects of different forms of taxation. The chapter should provide the interested reader with an understanding of the economic working mechanisms of cannabis regulation and insight into the potential dimension of different regulation scenarios for Switzerland.

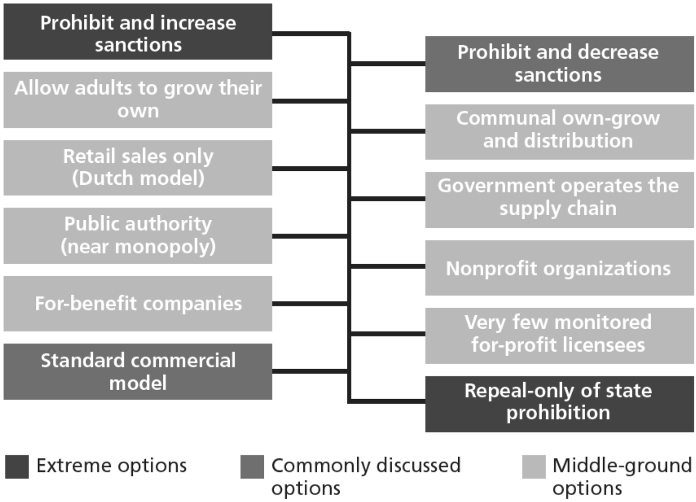
Figure 17: The spectrum of substance regulation between prohibition and unregulated for-profit models[59]



To do so, I have based the analysis of economic regulatory effects on a model that broadly distinguishes various regulation scenarios, as they are discussed both in politics as well as in academia. Some of these scenarios also resemble specific national and/or regional approaches taken by other countries. While these scenarios can significantly diverge in specific regulatory variables, even within any single scenario, they do share a common set of traits, which allows for a more structured analysis.Figure 19 shows twelve different forms of regulation, that cover the spectrum shown in Figure 18 from a strict prohibition with severe sanctions to a "free" market on the other side of the spectrum.

[59] Reproduced with kind permission by the Global Commission on Drug Policy (2014, p. 27) based on Marks (1987).

Figure 18: Regulatory bandwidth for cannabis[60]



Since the aim of this chapter is to simulate and discuss the economic effects of different forms of regulation, I have selected scenarios for the analysis, that cover a wide array of regulatory variables that were chosen for economic reasons. As this chapter will show, there are strong links between the economic perspective and other regulatory perspectives. The first part of this project has shown, when considering any form of non-prohibition-regulation, some key questions, that will significantly impact the economic effects associated with cannabis in Switzerland are:

- What does the supply chain for cannabis look like?
- Who can produce and/or import cannabis in Switzerland?
- How will cannabis be sold/distributed to consumers and who will do so?
- Who is allowed to consume which and how many cannabis products?

[60] Reproduced with kind permission from Caulkins et al. (2015a).

- What form of taxation will be applied and if so, how? (ibid, p. 4)

This is not to say, that other regulatory variables do not have an economic effect. On the contrary, the form of regulation does significantly impact if, what form, how, how much and by whom cannabis is consumed, especially across time, which in turn has economic consequences by changing demand. Because this analysis deals primarily with the status quo, the most immediate and significant economic changes from a purely quantitative point of view are to be expected from changes to the supply chain, the retail market and from taxation/economic regulation.

The focus on the economic side of regulation does not mean, that other perspectives on the question of cannabis regulation such as the view from the public health, legal and criminological side are not relevant. On the contrary, the question of how cannabis ought to be regulated is interdisciplinary and ought to be thoroughly discussed including all relevant facets. I hope to contribute to this process by providing some insight for the economic side of the discussion.

5.1 CANNABIS REGULATION SCENARIOS

In order to select scenarios for the comparative economic analysis I have reviewed academic and professional literature in Chapter 5.1 dealing with comparative regulatory approaches. Chapters 5.2 to 5.4 on the other hand describe the stylized scenarios in greater detail and present the results for each simulation. Chapter 5.5 concludes this section and summarises the results of the individual scenarios and compares them to the status quo.

Cattacin et al. (1996) compare 6 different drug policy approaches, one of them in the Canton of Valais in Switzerland. They conduct a network analysis of involved stakeholders and focus on aspects of prevention, therapy, research, control/repression and coordination of effort. They look back into the development of European drug policies since the 1970s and report an *institutionalization and rationalization* of policy approaches. Additionally, they find a *normalization* (p. 176) of the topic of illegal drug consumption, a path which – even though it preceded the current debate on regulation of cannabis use – *directly links to the current debate on cannabis regulation*. Taking into account organisational forms and value system of different countries, Cattacin & Philibert (2016) updated this approach comparing the Netherlands, the USA, Germany and Switzerland in their approach and rationale towards (substance-specific) drug-regulation.

An overview of demand and supply side enforcement policies in Europe (with a case study for Switzerland) as well as their economic rationale was conducted by Braun (2000). He concludes that while prohibition in general should increase market prices and thus reduce consumption, prohibition at the same time causes significant secondary problems such as illegal markets, high private and social costs for addicted consumers, ensuing crime and public nuisance. These side effects were addressed in the 1990s by Swiss cities through the controlled provision of heroin and centralised consumption infrastructure, a project also described by Frey (1997), who further discusses the possible policy implications of this approach for the European context. The aim of these projects was to improve the economic, social and health situation of addicts as well as to tackle the problem of public nuisance. A legal but limited-supply approach thus is one regulation approach that has been tried in the past. Based on this approach a project was developed by Geneva, Bern, Basel and Zurich which tried to establish private production and consumption cooperatives for cannabis as inspired by similar approaches for example in Spain, where several such *Cannabis social clubs* (CSC) exist. With the ongoing debate on the legality of social, pharmacological and economic experimental projects with regard to cannabis in Switzerland (Schweizer, 2018), these initial ideas are now more differentiated (Trelle & Teuscher, 2017). The publication of Herzig et al. (2019) analyses the current legal situation of cannabis in Switzerland and the legal enforcement across its 26 cantons and concludes that the status quo is contra productive in different ways. Heterogenous application of legal enforcement, no or little influence on product quality and associated health risks are some of the factors, that they identify in relation to the current regulation.

The changes to the drug policy approach in certain countries, specifically regarding the prohibition of cannabis, are also the subject of Philibert & Zobel (2019). The project aims to analyse the discourses and the processes that have led to changes in cannabis regulation in other countries to identify the reasons for this shift toward a "risk management" approach of governance. Another study using a comparative approach has been conducted by Zobel & Marthaler (2016). In addition to the detailed comparison of international regulation approaches they discuss both the background of the respective discussions that have led to change in regulation as well as potential and factual problems associated with various forms of regulation.

Such comparative studies are of particular relevance to this project, as the analysis of regulation policies in other countries directly connects to the methodology of this project by serving as a basis for the discussion and construction of the regulation scenarios.

With the recent changes in cannabis regulation in various countries, the authors have condensed the experiences and discussions on the various regulatory variables into coherent works that not only summarize the various forms of regulation in existence but also discuss hypothetical scenarios and problems associated with chosen regulatory approaches.

To conduct the comparative analysis in this project, the following regulatory scenarios are compared in their economic effects:

- **Prohibition with minor elements of decriminalization (status quo)**

  This scenario constitutes the baseline for the analysis and quantifies the economic effects under a regulation where all elements of the cannabis supply chain are prohibited (production/import, trade, consumption/ownership), with differentiated severity of sanctions. This includes the recent introduction of elements of decriminalization (such as the spot fines for people stopped with less than 10 grams for individual consumption introduced in 2013).

- **CSC-Scenario: Legalisation of cooperative production: Cannabis Social Clubs (CSC: Spain, Belgium, Uruguay)** [61]

  The production (and sometimes consumption) in self-organized production cooperatives is currently practised in different countries worldwide. While the details and the legal status differ between jurisdictions, these clubs tend to have in common that the production, distribution and/or consumption of cannabis is organized in (registered) clubs for adults. CSCs thus represent one form of regulating production and trade on a non-commercial level[62]. I simulate a cannabis market where de-facto legal and uncommercial CSCs exist parallel to legal home-grown supply and an illegal market. This scenario is based on the assumption, that CSCs/homegrown will provide the majority supply for heavy and regular cannabis consumers while the illegal market covers most occasional users.

- **High-Regulation Scenario: Commercial legalisation with high taxation and public health-oriented cannabis-specific regulation (NZ)**

  This scenario assumes a legal market with cannabis-specific regulation, private sector production and trade and legal consumption and ownership. I assume a form of not-for-profit operating licenses (non-monopolies) for private sector

[61] There are significant differences between the forms of CSC in these countries. While some developed in legal grey areas and are, legally speaking, still illegal but partially tolerated (e.g. Spain), others are officially regulated and operate within a legal framework; e.g. Uruguay, see Pardal et al. (2019); Queirolo et al. (2016). Another issue is the availability and legality of alternative forms of cannabis (e.g. in dispensaries or home-grown).

[62] Other similar forms are legalised forms of homegrowing or publicly run or organized dispensation of cannabis.

entities selling to Swiss residents in specialised shops. Additionally, a taxation scheme based on the former[63] taxation of CBD Cannabis taxation (excise tax) in Switzerland is applied that is based both on weight as well as retail value. This scenario is based on the recent referendum for cannabis regulation in New Zealand (J. P. Caulkins, 2018; Cox, 2018; Hajizadeh, 2016 Wilkins, 2018; P. Wilson, 2020).

- **Free-Market scenario: Commercial legalisation with for-profit market and little cannabis-specific regulations (individual US States)**

  The last scenario is a legal market with standard regulations comparable to other consumer products. Cannabis-specific regulation is kept at a minimum to resemble the last two options of Figure 19. It assumes a market with for-profit private sector companies providing production, processing, and trade of cannabis products. Consumption and possession for personal use are also assumed to be legal, no substance specific taxation and no restrictions regarding pricing, quality, or availability/eligibility except for age-limits. Cannabis would be produced and sold through common retail channels like other plant products for consumption such as parsley. There is no specific form of taxation applied except a standard VAT rate.

There are several other forms of regulation that are being discussed and/or applied in other jurisdictions (e.g. a complete prohibition with severe penalties or approaches with wide decriminalisation but without legalisation). A more repressive system for example would likely increase the costs of policing and in the judicial system, including the social costs for the consumer associated with having a criminal record. At the same time, a limited effect on consumption and market structure compared to the status quo is

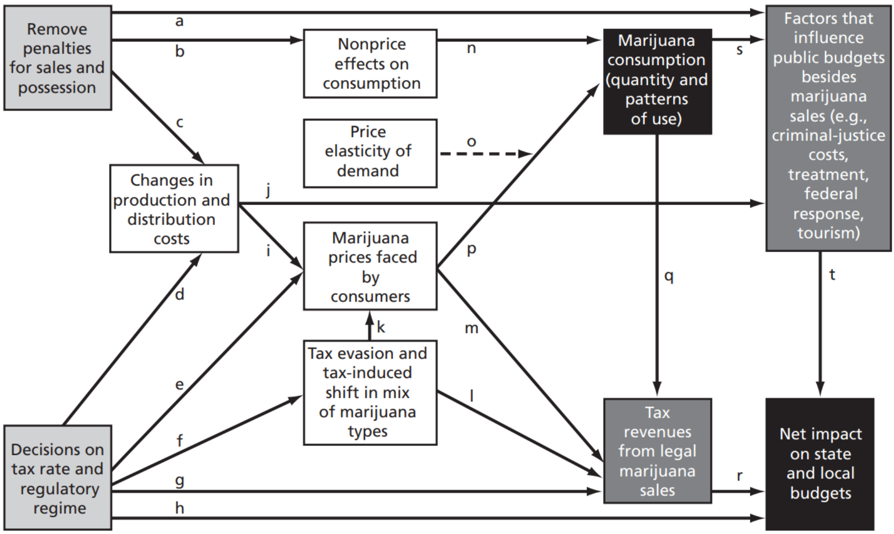
[63] It is important to note that the federal court of Switzerland has decided in January 2021 that the taxation of CBD-Cannabis as a tobacco-replacement-product, as it was handled up to that date, is not legal (Bundesgericht, 2021). Further information on future forms of taxation was not available at the time of writing.

to be expected (Lenton, 2000, 2005). A wider-reaching decriminalisation of cannabis-related offences compared to the current regulation on the other hand would likely reduce the costs of policing and in the judicial system and again have little impact on market structure and consumption patterns (Donnelly et al., 1995; Scheim et al., 2020; Single et al., 2000). The reason why such approaches were not further investigated in this project is thus not because they do not warrant a more detailed discussion or present valid regulatory options but rather because, economically speaking, they differ very little in their effects, from the status-quo or the selected scenarios respectively.

Recent development in various countries around the world, which have changed their regulation entirely or at least specific aspects of it, have not only spurred research into the topic, but also provide a glimpse into the quantitative effects, that different forms of regulations have in the short term. Nonetheless, there is little evidence and research on the long-term changes of regulatory change because there have been very few cases where regulation was significantly changed over the past few decades. To circumvent this issue, I will focus in our analysis on medium-term changes. Longer term aspects will be addressed qualitatively but will not be covered in the quantitative analysis.

A large share of the academic literature dealing with regulatory questions of cannabis stems from the U.S. One of the factors for this is the dynamic that various U.S. states have shown over the last two decades with regard to cannabis regulation (Leung et al., 2018; Zobel & Marthaler, 2016). While cannabis production, trade and consumption remains de-jure illegal on the federal level, 29 states have regulated the use of medical cannabis (Dioun, 2017) and 8 states have legalised retail trade of cannabis (Leung et al., 2018). This has led to a regulatory conflict between federal and state regulation that remains unresolved (Jacobs, 2016; Jaeger, 2021; National Public Radio, 2018). These dynamic changes in policy have spurred research on the issue of cannabis regulation. While transferring research results from one jurisdiction/culture to another warrants meticulous attention to detail, conceptual work can be transferred more easily and be of aid when thinking about the effects of cannabis regulation. For the discussion and analysis of regulatory effects for the scenarios outlined I am using an analytical framework (Figure 20) that was developed by Kilmer et al. (2010) in the wake of the discussion about cannabis legalisation in California.

Figure 19: Analytical framework for the effects of cannabis regulation[64]



The framework outlines several regulatory topics as well as potential links and effects between the regulatory topics. It constitutes a roadmap that I have used for both structuring the regulatory scenarios as well as for the estimation of the potential effects. The influence on the non-market segments (a,t) is discussed in in chapters 5.2 to 5.5, potential nonprice effects (b,n) in chapter 5.1.5 and the price elasticity of demand (o) and its effect in chapters 5.1.5 and 6.4. Additionally potential forms of taxation and their

[64] Reproduced with kind permission from Kilmer et al. (2010).

impact on revenues (d,e,f,g,h,k,l,r) are addressed in chapters 5.1.3 as well as 5.2 to 5.4 whereas the effects of production and distribution costs (j,i) are covered in chapters 5.1.1 to 5.1.3

The following chapters will contain a description of the assumptions and variables used for each of the regulatory scenarios, a breakdown of the results and the various effects as well as a discussion on the limitations and unknown factors. Since the calculations, assumptions and results of the baseline scenario are laid out in detail in chapters Chapter 3, they are not reiterated here again.

All the regulatory scenarios are based on the *ceteris paribus assumption*. This means, that only a limited number of variables are changed, for any given scenario while all other variables are assumed to be equal to the status quo.

The following chapters outline the regulatory frameworks assumed for each of the scenarios as well as the estimated economic effects and a discussion of the results. Before going into the details for each of the scenarios, the general parameters used for the estimation are outlined.

5.1.1 Domestic production and retail prices

For the CSC scenario (non-commercial legalisation of cooperative production through Cannabis Social Clubs) there are two different domestic production prices: the production price in the CSCs and the production price on the illegal market.

Since both policing intensity and the legal repercussions for narcotic law transgressions remain similar, the cost structure of illicit domestic producers is assumed to be identical to the status quo where the cost structure is estimated at a mixed rate for small, large, professional, and amateur production. Intertemporal macroeconomic effects such as technological progress, labour costs development and changes in the exchange rate are not considered as they are not specifically related to the regulation under investigation.

While economic theory would suggest that the existence of cheaper, legal cannabis from CSCs could spur price competition and reduce retail prices in the illegal market, market data from jurisdictions with decades of CSC-experience does not seem to support this hypothesis (European Monitoring Centre for Drugs and Drug Addiction, 2020b; UNODC, 2017).

It is important to note that there are several limitations to this comparison. The first being that it is unclear what share of total demand per country is covered by CSC supply. This would be an important information to determine the market share covered by CSCs and in extension, the potential pressure exerted on prices. The second is that the price differential between obtaining cannabis through a CSC vs. the illegal market depends on the actual operating model of the CSC which can be different even within a given country and can only be compared on a club-by-club basis. The third factor is that the policing strategy and the judicial focus of the persecution for cannabis production and trade related offences could be different and influence the interaction between the legal and illegal market. The fourth is that the illegal-market price is affected by any given countries place in the international supply chains. Countries at the south-eastern and south-western "entrance" of Europe tend to have lower import prices when compared to for example Switzerland or Scandinavia (see Chapter 3) and thus the price differential between the illicit and licit market is likely smaller (see Figure 24, page 202).

Another issue which could also hinder the influence of price pressure from the CSCs pertains to product differentiation. Price convergence between two markets or products rests on the assumption, that the goods have a very high degree of substitutionality. Given how many factors influence the attractiveness of a CSC it is possible, that obtaining cannabis from a CSC is simply not considered sufficiently like obtaining cannabis from the illegal market. Some issues influencing the valuation of both products are for example: product quality, product accessibility, convenience, risk and legality, purchasing restrictions, transparency and privacy concerns or other non-price issues such as club requirements with respect to registration or control. Finally, it is important to consider, that the non-monetary "production costs", the risks associated with illicit production and import (detection, seizure, legal consequences), constitute a theoretical price floor for the retail prices in the illicit market which is higher, than in the licit market (assuming equal monetary production costs). When retail prices fall, there comes a point on the supply curve where illicit production cannot compete with licit prices anymore, since the risk/reward ratio is not sufficiently attractive anymore for illicit producers/importers.

Because there is not enough evidence on the relationship between CSC-pricing and illegal market pricing and there are valid arguments against the theory of price convergence, I have decided to disregard a potential influence between the two markets for the sake of this estimation. The scenario is thus based on the assumption, that there are two coexistent markets, one legal (CSCs) and one illegal with both retail and production prices being smaller in the CSCs.

This assumption is based on several factors. The first being the legal framework in which CSCs can operate. Due to the non-existent mark-up for illegal activity (possibility of detection and seizure, security measures, etc.) production costs will be lower than on the illegal market. The second factor is economies of scale. Because the production capacity of the club is bound to the number and consumption habits of its members, the size of a club with 100 frequent consumers could easily be several hundred plants which would put it at a medium size plantation according to police interviews and interviews with industry experts and grow-shop operators. Because the CSC production can operate legally, at scale and draw on expert input in growing and production, it is likely, that the growing operations will be at the professional end of the spectrum. These factors combined as well as the information provided by cannabis producers in Switzerland leads me to assume an average production price of 1.500 CHF/kg for marijuana[65]. This is cheaper than the current estimated illegal market structure, but still significantly more expensive than a legal commercial/industrial production setting. The production price could potentially be higher, depending on the specific production regulations that can be applied (e.g. GACP) (Lardos, 2021b, 2021a). Nonetheless, cannabis producers familiar with the regulatory frameworks and data from other jurisdictions with established production regulations estimate that regulatory and security costs will not exceed a low, single digit percentage of production costs in the medium term. It is unlikely that the production cost would exceed 1.500-1.800 CHF/kg (Deloitte Access Economics, 2016; Kilmer & Burgdorf, 2013; S. Senn & L. Cereghetti, personal communication, 4 June 2021).

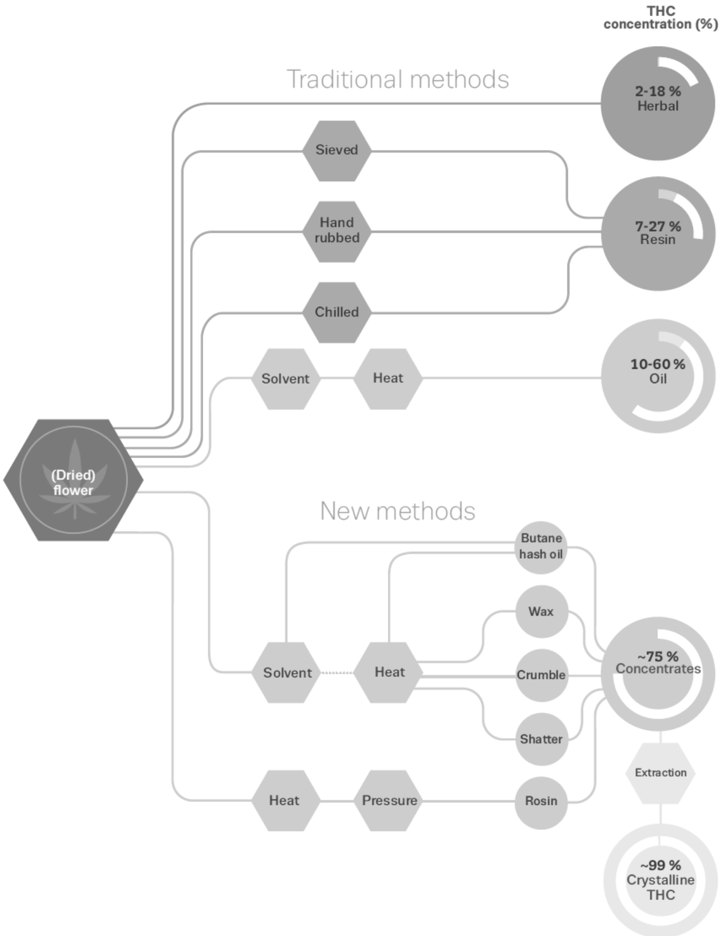
Resin production in CSCs is assumed to be a side product of marijuana production, as it can be obtained by both processing leftovers plant parts from the marijuana production. While this is not the most productive form production in terms of output, the net addition in this particular form of production in terms of production costs is only the processing of the leftover material, as the growing, harvesting and (potential) drying is already covered in the marijuana production. There are other production forms (see Figure 21), which are focused solely on resin production and are more productive in terms of output, but these forms require the usage of the entire plant/buds (e.g. hand rolling). However, as the demand for resin in Switzerland is relatively low, compared to marijuana, I assume the demand is met first and foremost by processing marijuana waste material, as it is the most cost efficient form of production and can easily be scaled based on the amount of plant material available. Since production from waste material cannot fully satiate the theorized demand for resin of the CSC

[65] This is estimated including labour costs and already considering a mixed portfolio of club sizes including small and large production operations. Nevertheless, the production costs are estimated conservatively and remain comparably high, given legal production costs.

users, I assume that the remaining demand is fulfilled by substituting with marijuana.

For the final processing of resin from waste material, 10% of marijuana production costs are assumed based on the interviews with cannabis producers. It cannot be ruled out, that changes in demand could potentially increase resin demand to a point where demand cannot be met by supply from residual plant material alone and other production methods would be applied. However, as this remains a hypothesis and the economic consequences of additional, solely-for-resin production of cannabis are limited, this case will not be simulated specifically.

Figure 20: Overview of production methods for various cannabis-based products[66]



For the High-Regulation and Free-Market scenarios that simulate commercial forms of production and trade significantly lower

[66] Reproduced with kind Permission from the European Monitoring Centre for Drugs and Drug Addiction & Europol (2019, p. 87).

production costs are assumed compared to the status quo and the CSC scenario. This is based on multiple factors. In comparison with the CSC scenario a more professional supply chain is assumed, with industrial scale production that will be able to realise higher economies of scale. In addition, I assume an increase in competition, which will additionally drive prices down. Because the High-Regulation scenario contrary to the Free-Market scenario assumes a highly regulated market with respect to accountability, taxation, product quality, etc. production costs will be higher in comparison. For the High-Regulation scenario I assume average production costs of 1,200 CHF/kg whereas the Free-Market scenario is set at 500 CHF/kg[67]. Both scenarios assume a mix of indoor, greenhouse and outdoor production with associ-ated labour cost shares. These estimations are based on the information obtained from police interviews, CBD producers in Switzerland, cannabis producers abroad, industry associations and literature on the topic (Caulkins, 2010; Caulkins et al., 2018; European Monitoring Centre for Drugs and Drug Addiction & Europol, 2019; European Union & European Monitoring Centre for Drugs and Drug Addiction, 2019; M. Mosimann, personal communication, 31 May 2021; S. Senn & L. Cereghetti, personal communication, 4 June 2021).

5.1.2 Operating and distribution costs

The intermediate inputs for operating the club and the distribution of cannabis are assumed to be the median between the status quo (see chapter Chapter 3) and the legal commercial market in the Free-Market scenario (see chapter 5.4.). The other components of value added for operating the club and distribution are estimated in relation to the intermediate inputs based on the ratio between

[67] It needs to be noted, that this is still a conservative estimate, in the sense that it could potentially be lower. Outdoor CBD cannabis for example is being produced and traded at wholesale level at prices below 300 CHF in Switzerland at the time of writing.

intermediate inputs and value added for the legal commercial market in the Free-Market scenario (see chapter 5.4.). For the High-Regulation scenario, the operating costs are estimated to be the mean between the Free-Market scenario and the CSC scenario to reflect the increased degree of professionalisation.

5.1.3 Retail costs and taxation

Cannabis products could be taxed in multiple ways. The most commonly distinguished product-specific forms are ad-valorem excise taxes (based on the value of the underlying asset), weight-based excise taxes (based on the weight of the underlying asset) or potency-based excise taxes (based on the potency of the underlying asset, e.g. regarding THC). Non product specific taxes such as VAT also play a role in the discussion.

One advantage of weight-based taxes is the fact that they remain fairly stable, even when the prices of retail products fluctuate (as is to be expected for cannabis products). However, it is necessary to determine, what part of the product exactly gets taxed at what stage of the supply chain. California for example "*levies a $9.65 per ounce tax on marijuana flowers, a $2.87 per ounce tax on marijuana leaves, and a $1.35 per ounce tax on fresh plant material*" (Tax policy center, 2020). Weight based taxes also have advantages from an enforcement perspective, as they are usually collected early in the supply chain and thus only apply to a limited number of producers (C. Davis et al., 2019). Another issue, which makes weight-based taxation an attractive choice is the fact that it is a taxation scheme that is fairly robust, even if the actual retail products being sold start to diversify (ibid.). When thinking about the wide spectrum of cannabis based products (see Figure 21, page 181) that appeared on the market after Cannabis was legalized in various U.S. states (Caulkins et al., 2018; J. M. Davis et al., 2016; Ghosh et al., 2017) it is obviously easier to tax the product early in the supply chain (e.g. at harvest weight or dried weight) than at a later stage (e.g. as a cookie or as oil), especially since an ongoing diversification would require a constant adaption of the tax scheme.

The disadvantage of weight or value-based taxes are the fact that they have limited options[68] in terms of adjusting taxation for the potency of the product. This is where potency-based taxes come into play. Assuming the analytical capacities and regulations are in place for a reliable determination of THC content in any given product, it would be possible to link the excise tax rate to the potency of a product, as it is for example being done for beer in Switzerland. While light beer is taxed at 16.88 CHF/hl, normal beer is taxed at 25.32/hl, strong beer at 33.76/hl[69] (Federal Customs Administration FCA, 2021b). Anderfuhren-Biget et al. (2018) make another point related to the aims of taxation. Regardless of the exact form of taxation, the tax scheme applied can also be used to incentivise and disincentivise particular forms of consumption. If for example, from a public health perspective, some forms of consumptions are more damaging than others (e.g. smoking and lung cancer) or are more likely to incentivise children and adolescents, these forms could be taxed specifically, to influence the decision making mechanisms by price changes. A good example, where this is done for precisely this purpose, is in the taxation of “alcopos”, which are taxed at four times the rate of normal liquor in Switzerland (Federal Customs Administration FCA, 2021b). As these were predominantly consumed by teenagers and adolescents, and had a fairly high alcohol content, the government stepped in and disincentivised the sale of these products in comparison to other substitute products.

The third approach to taxation is ad-valorem taxes or taxes based on the retail and/or wholesale level. While they generally always capture the same share of the price (just as VAT for example), the actual tax revenue can decrease significantly, if the price of the product decreases, assuming constant consumption (C.

[68] For example by taxing differently potent parts of the plant differently (buds vs. leaves).

[69] It is important to note that in terms of taxation the potency of the product for beer is not measured by alcohol, but by the gravity of the beer. However, gravity and alcohol degree are somewhat related and as a rule of thumb a beer with higher gravity generally has a higher alcohol content.

Davis et al., 2019). This could lead to a situation, assuming constant tax rates, where tax revenues are high, in the early stages of the development of a legal market, but they decrease, as the industry matures and prices drop (Boesen, 2020). Another issue for value based taxation can be vertical integration of cannabis production and trade and the potential for creating incentives to circumvent taxation through transfer pricing within the same organisation (C. Davis et al., 2019).

The different forms of taxation are not mutually exclusive, and can be combined, as it is for example being done for tobacco in Switzerland. For a package of 20 cigarettes that is being a sold at an average retail price of 8.60 CHF, 2.36 CHF tax is added based on the weight of tobacco at the stage when it is packaged as a consumer product and 2.15 CHF tax is added based ad valorem yielding a total tax of 4.51 CHF per package (Sektion Tabak- und Biersteuer, 2020). In addition to the tobacco tax, which is used to finance the AHV (pension, widow and disability insurance) in Switzerland, 0.13 CHF/cigarette or 1.73/kg for cut tobacco is levied for both a fund to prevent tobacco related health issues (Tabakpräventionsfonds) and a cooperative for the purchase of domestic tobacco (SOTA) (Schweizer Bundesrat, 2015). CBD Cannabis has been taxed as a tobacco replacement product for many years, until the federal court of Switzerland decided that this was not in line with the laws governing the taxation of tobacco replacement products (Bundesgericht, 2021).

The answer to the question of how to tax cannabis depends on a lot of factors. The most relevant being the goals, that are supposed to be achieved by alternative forms of regulation (e.g. remove the raison d'être and the negative externalities associated with illicit markets). Other issues such as enforcement, flexibility and the practicability of taxation need to be considered as well. Last but not least, country specific aspects such as the relationship between cantons and the federal level (Anderfuhren-Biget et al., 2018; Caulkins, 2017), a potential tax-race to the bottom, and the multilateral relationships and international taxation agreements that Switzerland is bound to, need to be considered too (Van den

Ende, 2016). This international aspect does not only pertain to questions of taxation, but also to questions of legality with respect to UN drug control treaties related to cannabis legalization (Bear, 2017).

Just how crucial the question of taxation is, is shown by the data presented in Figure 22. The data is from an opt-in field survey conducted in Washington in June and July 2013. While the data sources is not representative for the whole state (Kilmer et al., 2013), it still provides valuable insight.

The figure shows the percentage of respondents in each prevalence group, that said they were willing to pay x USD as a premium for legal cannabis in comparison to cannabis from the illicit market. The most striking result is the fact that more than 46% of very frequent users (21-30 days/last 30 days) are not willing to pay a legality premium of 2 USD or more and close to 38% are not willing to pay even a little bit more. While this data is obviously to be taken with a grain of salt and cannot simply be adapted to Switzerland, I presented this information in my interviews with producers, industry experts and grow shop operators and they confirmed a similar sentiment. Even in Switzerland, according to my interviews, there is a considerable share of frequent and very frequent consumers with a very low willingness to pay even a small premium for legal cannabis. This is unsurprising because an increase of only 1 CHF/g would increase average annual costs of consumption in excess of 250 CHF for this group.

If regulation intends to make the illicit market superfluous, it thus needs to ensure, that the product in the legal market is safer, better, easier accessible and cheaper or evenly priced to a potentially competing dynamic illicit market.

Figure 21: Willingness to pay a legal premium in comparison to illicit market price per gram [70]

	Past-Month Use-Days			
Premium ($)	1–3 (median = $4; mean = $7.22; 157 respondents)	4–10 (median = $5; mean = $9.52; 190 respondents)	11–20 (median = $4; mean = $6.30; 193 respondents	21–30 (median = $2; mean = $3.59; 828 respondents)
>10	17.2	15.3	10.9	8.0
5–10	31.9	44.2	38.3	27.9
3–5	8.3	8.4	5.7	5.2
2–3	13.4	10.0	13.5	12.7
1–2	7.6	6.3	9.3	7.0
0.01–0.99	0.6	0.0	0.0	1.5
0	21.0	14.2	20.7	35.5
<0	0.0	1.6	1.6	2.3

However, the purpose of this project is not to find an ideal solution to the taxation question, but rather to estimate the potential bandwidth of stylized approaches of taxation. For the purpose of this estimation three different forms of taxation were selected.

In the CSC scenario a taxation scheme that is similar to gambling taxation in Switzerland is applied. Casinos are taxed in Switzerland based on their gross gambling revenue (the difference between gambling revenues and the paid-out price money to gamblers). It is set in a way that enables sensibly run casinos to achieve an adequate return on investments and the revenue is used to finance the AHV (pension, widow and disability insurance) (Eidgenössische Spielbankenkommission, 2020). I am applying the same concept to cannabis and apply a value-based sales tax of 60% as well as regulated retail prices of 7 CHF/g for marijuana and 8 CHF/g for resin. This taxation scheme allows for CSCs to cover costs, investments, return on capital and some excess funding for risk management and member activities whereas the remaining surplus value added is taxed and can be diverted to fund

[70] Reproduced from J. Caulkins et al. (2015), see Kilmer et al. (2013) for additional background on the data.

healthcare, prevention and other forms of public-health oriented measures.

In the High-Regulation scenario I assume a taxation scheme that is based on the previously applied taxation of CBD cannabis and tobacco in Switzerland with VAT and an excise tax on both weight and value adjusted to the current retail prices. However, the tax will be significantly higher than previously, to simulate a retail price at current illicit market prices.

In the Free-Market scenario I assume no production specific taxation scheme but instead solely calculate the VAT effects based on the average taxation of similar agricultural products such as parsley.

Table 28: Overview regulatory scenarios

	Status Quo	CSC	High-Regulation	Free-Market
Legality				
Consumption/Possession pers. use	Spot fines	legal	legal	legal
Production w/o comm. intent	illegal	legal	legal	legal
Production with comm. intent	illegal	CSC only	legal	legal
Possession, trade with comm. intent	illegal	CSC only	legal	legal
Export, Import, Transit	illegal	illegal	illegal	illegal
Market assumptions				
Share of consumption qt. from illicit market	100%	38%	0%	0%
Consumption quantity (excl. Homegrow) in t	52.8	56.4	52.8	70.1
Homegrow qt. in t	3.2	3.5	2.5	2.2
Import share of illicit market share	33% (m), 100% (r)	33% (m), 100% (r)	0% (m), 0% (r)	0% (m), 0% (r)
Retail price (marijuana/resin) in CHF/g	10 / 13 CHF	7 / 8 CHF	10 / 13 CHF	0.86 / 0.36 CHF
Production costs marijuana* CHF/kg	2,360	1,500	1,200	500
Taxation	None	Fixed price and 60% of revenue as sales tax, no VAT	4.8 CHF/g (m) 7.9 CHF/g (r) + 43%+7.7% VAT of pretax value	7.7% VAT
Economic components in m CHF				
Int. Inp. dom. prod.	42.4	46.0	35.8	19.8
Int. Inp.dom. trade	10.0	12.5	8.6	5.5
Dom. prod. GVA	190.0	119.8	49.0	29.0
Import value	147.6	36.0	0.0	0.0
Int. Inp. trade imports	9.5	4.0	0.0	0.0
Import GVA	179.8	76.0	0.0	0.0
Prod. Taxes	0.0	147.5	453.9	4.2
**including labour costs*				

These assumed taxation scenarios are not meant to be realistic scenarios for the taxation of cannabis in alternative regulatory scenarios. Instead, they are supposed to show the range of tax impacts using different approaches. The actual taxation of cannabis in an alternative regulatory scenario needs to consider a host of other factors and will likely be far more specific and directed to achieve specific public-health and -finance oriented goals.

5.1.4 Homegrow-substitution

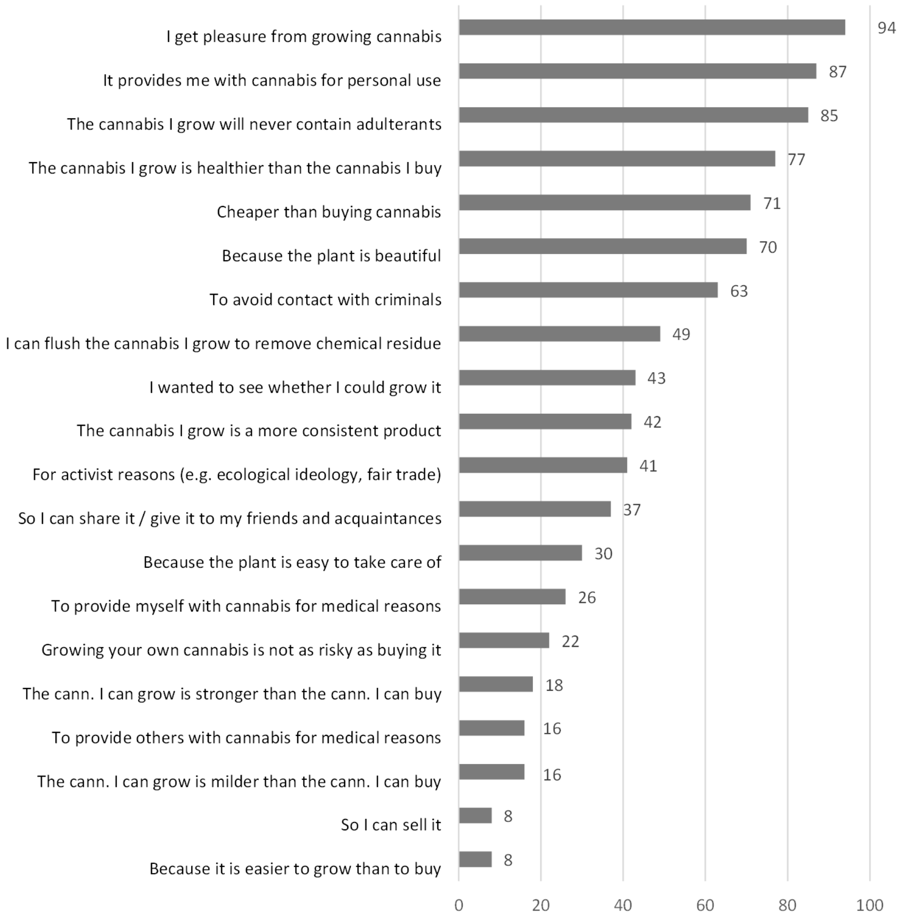
In the status quo, it was estimated that a share of cannabis demand in Switzerland is covered by homegrown cannabis (Table 6). For the estimation of how homegrowers could be affected by the regulatory scenarios it is important to understand, why homegrowers are motivated to produce cannabis. The Directorate General for Justice of the European Commission (2013, pp. 95–109) extensively reviewed the primary research on homegrower and homegrower motivation in various European countries and broadly distinguishes homegrower with commercial intent and non-commercial growers. Additionally they show, that the share of homegrowers motivated by financial gain is a minority (Decorte, 2010; Hakkarainen et al., 2011; Potter, 2006). Country data for Switzerland from an international survey supports this theory (Figure 23). A more detailed analysis and comparison to Germany and Austria was conducted by Werse (2016).

The hypothesis of a low degree of commercial intent it is contrasted by information I received in my interviews[71]. A lot of homegrower in Switzerland receive their equipment and intermediate inputs from so-called grow shops. These shops sell almost everything that is required for cannabis cultivation and also serve as a place for know-how transfer and information on cultivation. The operators of said stores thus have a good understanding of

[71] Anonymous informant #1, personal communication (2 April 2021); Anonymous informant #2, personal communication (15 February 2021); S. Senn & L. Cereghetti, personal communication (4 June 2021).

the growth operations that are being set up both in terms of technique, capacity, and motivation. In the interviews I conducted, the very low share of only 8% of people mentioning an intention to sell in the survey was doubted. My interview partners mentioned estimates of about 33-66% of growing operations that would exceed the size of personal consumption and are used either for the sale of the overproduction or the non-commercial distribution within the social circle of the grower (e.g. forms of cooperative production).

Figure 22: Motivation for homegrowing cannabis in Switzerland in %[72]



There are two likely hypotheses why the share of respondents claiming to produce with intent to sell might be too low in comparison to the interview estimates. The first could be due to a sampling issue and the second is because production with the intent

[72] Data by Potter et al. (2015, p. 182) country sample size Switzerland n=101.

to sell is an activity that carries significant legal consequences in Switzerland. Admitting to this honestly, even in an anonymous web survey could thus be too much of a perceived risk for the respondents. This hypothesis was also confirmed by another interview (Sven Schendekehl, personal communication, 4 June 2021) where it was mentioned that survey-based primary research in the "cannabis community" is problematic, as there are very strong reservations by regular consumers and illegal producers to both participate and answer honestly.

However, the question why people grow cannabis themselves is more complex, than the binary choice between commercial and non-commercial motivation. The data in Figure 23 as well as other primary research on the topic (Decorte, 2010; Hakkarainen et al., 2011; Potter, 2006; Werse, 2016) suggests, that there are more nuanced themes. Aesthetics and pleasure, product quality, cost savings and the avoidance of criminal contacts are frequently cited motivational themes. The desire to sell cannabis on the other hand ranks very lowly with only 8% of homegrowers mentioning it.

Unfortunately, the data availability on homegrown motivation, for Switzerland in particular, remains thin. While the survey data does provide some insight into the motivation behind homegrowing, it is not suited to derive a quantitative estimation on the effects of regulation. This is because there is no kind of prioritization of these reasons and there is some doubt as to the representativeness of the sample and the truthfulness of the responses.

To address the question at least on a qualitative basis I have broadly categorized the motivational themes into three categories based on expert interviews with cannabis producers, industry associations and cannabis interest groups in Switzerland. The number for each reason represents the percentage of mentions in Potter et al. (2015, p. 182).

Table 29: Expert input on the future of homegrow motivation in a legal retail market

Likely to not remain a significant reason in a legal retail market	**Mixed**	**Likely to remain a significant reason in a legal retail market**
Avoid contact with criminals (63%) Experiment (43%) Ease of growing (30%) Ease of access (8%) Provision of cannabis for medical purposes (26%) Provision of others for medical purposes (16%) Risk management (22%) Strength of product (18%) Mildness of product (16%) Easier to grow than to buy (8)	Adulterants (85%) Residues (49%) Healthiness (49%) Consistency of product quality (42%) Sharing (37%) Selling it (8%)	Pleasure from growing (94%) Personal use (87%) Cheaper (71%) Beauty of plant (70%) Activist reasons (41%)

While the number of reasons in the "not relevant anymore" column is largest, the list contains almost the entire bottom of the initial list from Figure 23 with the themes being mentioned by relatively few respondents. The themes that were almost unequivocally mentioned not to be relevant anymore in a legal retail market pertain to issues such as product differentiation (which will be addressed by production labels/standards and transparency about product potency), risk and illegality (as consumption and purchase is illegal) and ease of access. The experimental nature of home growing is, according to my interviews also primarily related to the illegal nature of cannabis ("forbidden fruit", see non-price effects) and will probably be a lot less relevant in a legal retail setting.

The mixed category contains three themes. The quality/healthiness of the product. Social aspects (sharing/selling) as well as the need for personal use. Concerning the quality aspects and "organic" factor of homegrowing my interview partners mentioned two issues. The first is that these reasons will probably continue to exist in the short to medium term but will eventually become less and less important as product quality, transparency, availability, and trust in the retail market increase over time. The second issue can be called "old habits die hard". A significant number of homegrowers, especially older and regular consumers, have been growing their own cannabis for years if not decades and it has become a part of their life almost like a hobby. According to my interviews it is highly unlikely that this group would stop doing so, even if a legal retail market would exist. The social motivations of sharing or selling cannabis is also assumed to fade out, if the price differential between legal and illegal cannabis is not excessively high. Homegrowers who produce (amongst other reasons) for these reasons would probably continue to do so for a while but the interview partners were sceptical whether new homegrowers would pick up producing homegrown cannabis for primarily social reasons if a legal retail market would exist.

These opinions also have some relevance when looking at the column for reasons that will continue to be relevant reasons for homegrowing cannabis in a legal retail setting. Pleasure from growing and the beauty of the plant as well as activist reasons are precisely the motives that my interview partners mentioned would continue to exist for many homegrowers, even if a legal retail market would exist. The other decisive factor for homegrowers is the cost savings that can be achieved by producing at home for personal use. The importance of this factor depends on two main factors: the consumption amount as well as the price differential between legal modes of obtaining cannabis and production costs at home.

As homegrowing will be legal in all three scenarios under investigation, there are three different effects to be expected with a newly existing legal basis for homegrowing.

- Some consumers, who have not done so before, will pick up homegrowing
- Some previous homegrowers will meet their demand through CSCs/the legal market
- Some people, who have not consumed cannabis before, will pick up homegrowing

Each of these groups has motivations associated with it. For group 1, likely motivations are personal use, costs and social reasons. For group 2 the core reason is likely convenience and group 3 is likely motivated by experimenting.

While the international regulatory landscape has changed in recent years and 27 jurisdictions have "*legalised, decriminalised or depenalised (de facto or de jure)*" homegrowing (Belackova et al., 2019, p. 44) by December 2018, there is little information on the effects of such regulatory changes with respect to homegrowing. There are two likely reasons for this. The first being the novelty of said regulatory changes and the second the lack or quality of data on homegrowing and the effect of regulatory change on homegrowing before (and potentially after) the change. As it was not possible to source a feasible basis for the estimation of the effect strengths of groups 1-3, I will rely on qualitative information provided by the interviews I conducted with police forces, cannabis producers and industry experts. The general consensus in the interviews was that the effect of group 1 is probably going to exceed the effect of group 2 with respect to number of persons. However, there was disagreement as to whether this would be the same regarding quantity produced. This estimation was often justified with the hypothesis that the people in group 2 will more likely be frequent to very frequent consumers whereas the people in group 1 will more likely be sporadic users. This is especially relevant as consumption patterns (and per assumed extension production patterns) differ sharply between these groups (see chapter Chapter 3). For all scenarios the degree of accessibility (see Figure 25) to the legal channels was mentioned as a central deciding factor. The better the quality, the lower the price and the more convenient the access to products on the legal market, the stronger effect 2 and the weaker effect 1 will be.

Another issue that was frequently mentioned was that regulatory change to homegrowing is probably going to have a fairly small or even negative effect on quantities produced at home, if it is accompanied by other attractive and legal channels of obtaining cannabis, as is the case to varying degrees in the regulatory scenarios. This was justified by the assumption that people who have a strong motivation to produce their own cannabis for self-sufficiency and quality reasons are doing so already and the assumption that the number of people who are deterred from homegrowing by the current policing strategy is rather small on the one hand and that the deterred people are on average probably on the lower end of the consumption spectrum. However, these statements contrast with survey data for Switzerland reporting that 15% of surveyed homegrowers already had contact with the police due to their growing operation and 23% estimate that the risk of getting caught is high (Potter et al., 2015, p. 187).

The third issue mentioned concerning the effects of potential homegrow-regulation is that it would make a significant difference, whether homegrowing is only permitted indoors/out-of-sight of the public (as for example it is proposed in New Zealand) or without specific restrictions in terms of location and visibility. It was mentioned by both grow-shop operators (Anonymous informant #1, personal communication, 2 April 2021; Anonymous informant #2, personal communication, 15 February 2021) as well as other cannabis experts (Sven Schendekehl, personal communication, 4 June 2021) that the uptake of homegrowing would likely be much larger, if homegrowing was permitted outdoors on balconies, rooftops, etc. This sentiment was based on both regular customer contact with homegrowers as well as with the experience during the early 2000s, when the regulatory and enforcement landscape of cannabis was more relaxed, and the residential small-scale cultivation of outdoor cannabis increased notably.

The last issue which was raised concerns both the legal risk associated with it as well as the perceived effects of enforcement (see Figure 25). Examples for these factors are the severity of legal consequences for overstepping threshold quantities, the perceived probability for house searches by police forces or the potential risk of enforced lab tests and the possibility of losing your driver's license in case of a positive test. Both form and focus of enforcement can shape the potential effects of legal regulation as shown in a comparative analysis between the Dutch and Czech cases by Belackova et al. (2015, p. 296):

> "Although the two policies are similar, their implementation differs substantially. In the Czech Republic, law enforcement has focused almost exclusively on large-scale cultivation. This has resulted in a competitive small-scale cultivation market, built upon a history of cannabis self-supply, which is pushing cannabis prices down. In the Netherlands, the costs of establishing one's own self-supply have historically outweighed the costs associated with buying in coffee shops. Additionally, law enforcement has recently pushed small-scale growers away from the market, and a large-scale cannabis supply, partly controlled by organised criminal groups, has been established that is driving prices up. The Czech cannabis prices have become relatively lower than the Dutch prices only recently, and the decision to buy on the market or to self-supply will be further shaped by the transactions costs on both markets, by policy implementation and by the local culture."

To summarize, it was not possible to determine a quantitative basis for the estimation of the degree of homegrowing substitution. Instead I have summarized the available literature on the topic and combined it with qualitative inputs from cannabis pundits for the Swiss market. In order to include the various arguments on the matter I have included a "guestimate" in the estimation. For the CSC scenario, I have increased the estimated amount of homegrown cannabis by 10%, including the converse effect by group 2. For the High-Regulation scenario and the Free-Market scenario however, I will reduce the amount of homegrown cannabis to simulate the significantly increased accessibility, quality and convenience of the legal market. The High-Regulation scenario will thus be estimated with a decrease of -10% whereas the Free-Market scenario is calculated at -25% to encompass the additional decrease in retail prices and thus the decrease in financial motives for growing at home.

It needs to be reiterated that these adjustments for the scenarios are used as a stylized estimation feature and needs to be interpreted as such.

5.1.5 DEMAND-SIDE EFFECTS

5.1.5.1 Elasticity of demand

The regulatory assumptions for this scenario can lead to various changes on the demand side, as well as with respect to the economic effects associated with the cannabis system. To estimate these effects, it is necessary to distinguish multiple factors, that are relevant for each of these regulatory scenarios.

The first factor is the price elasticity of demand for cannabis. Price elasticity is a concept used for estimating the change of consumption in response to a change in price. One issue, that is particularly relevant for the estimation in this project, is the difference between participation elasticity (how many people will start/stop participating in cannabis consumption given a change in the price for cannabis) and the total effect of price changes on the volume consumed (Kilmer et al., 2010). This is not the same, as the people who pick up or stop participating in cannabis consumption given any change in price are not necessarily "average" consumers with respect to their consumption pattern and quantity.

While the literature on the price elasticity of demand on legal drugs/substances is wide and thorough, this is unfortunately not the case for cannabis. An extensive review of the available literature on the topic was conducted by Ouellet et al. (2017, pp. 14–20) and finds:

> "A review of the literature suggests that participation and full price elasticity estimates vary with respect to the heterogeneity observed across different populations from which samples are drawn."

Another comprehensive summary of studies on the price elasticity of demand for cannabis was conducted by Gallet (2014) who identified 14 out of the 42 studies covering 462 observations and ran a meta-analysis of the findings. He concludes that "*the predicted price elasticity of marijuana is nearly half that of cocaine and heroin*" (ibid. p. 64) and estimates it between -0.16 and -0.29[73].

A core issue of the analysed literature on the effect of prices on demand for cannabis is the focus on prevalence rates. As chapter Chapter 3 and the international literature on the topic (e.g. Kilmer et al., 2011; Werb et al., 2012) has shown, the largest quantity of cannabis is consumed by the most frequent consumer groups.

> "This realization implies that knowledge of how prevalence rates change in response to a change in price may not be that useful for understanding how total consumption would change with a change in price because of the heterogeneity in users represented by any particular prevalence rate. To understand how total consumption (in terms of volume of the good consumed) changes, one needs to understand how behaviour among regular users and heavy users changes." (Pacula & Lundberg, 2014, p. 8)

The fact that estimations for price elasticities are different for specific groups of the population is in line with the academic on the literature which has shown differences for age groups, different past month consumption frequency and polysubstance users (Ramful & Zhao, 2009; van Ours & Williams, 2007; J. Williams, 2004; J. Williams & Mahmoudi, 2004).

[73] Based on a sample adjusted for outliers (442 observations).

A different approach to estimate the total price elasticity of cannabis is using an average, literature-based value for the participation elasticity and adjust it by using the ratio of participation to total price elasticity from similar goods such as tobacco. This is what Kilmer et al. (2010) did to estimate a total price elasticity of -0.54 (-0.3 participation elasticity for cannabis multiplied by 1.75) for the U.S. What this means, is that for a 1% increase in price, a reduction in total consumption quantity of -0.54% is expected and vice versa including both the price and participation effect. Similar approaches for estimating the total demand elasticity were conducted by Davis et al. (2016) using crow-sourced transactional data for the U.S. The resulting estimate of total price elasticity ranges between − 0.67 and −0.79. Lakhdar et al. (2016) on the other hand gathered primary data for more than 250 near-daily cannabis users in France and estimate "*a short-term price consumption elasticity ranging from −1.7 to −2.1*". For Canada Ouellet et al. (2017) use self-reported data from price of weed for Canadian transactions and estimate an inelastic demand between -0.42 to -0.60.

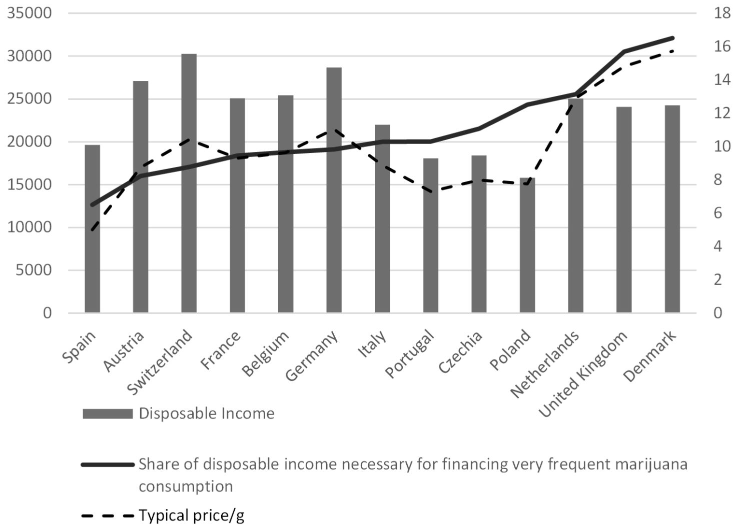
However, it is worth noting, that these estimates are usually based on a narrow price-range. Given the broad bandwidth of potential regulatory scenarios, there is an extraordinarily large range of potential prices for cannabis products ranging from low, single digit CHF/g estimates in a fully efficient, mostly unregulated commercial retail market to prices exceeding 15 or even 20 CHF/g in heavily regulated and taxed scenarios. Since quantitatively estimated price elasticities tend to be more accurate, if the changes in prices are relatively small the sheer width of the price range is a challenge and limits the estimation quality.

Another method to determine the sensitivity of demand to price changes are behavioural experiments. Amlung et al. (2019) ran an experiment with 724 respondents from U.S. states with legalized recreational cannabis who were asked to complete a marijuana purchasing task. They find that legal cannabis was (1) considered a superior commodity that there is (2) asymmetrical substitutability and (3) that the existence of legal cannabis significantly increased price sensitivity for illegal cannabis. These findings were replicated with similar results for a sample of adult cannabis users in Ontario, Canada (Amlung & MacKillop, 2019).

Is it possible to adequately estimate the reaction of demand to the pricing impacts of regulatory change? "*The honest answer is that we simply do not know*" (Pacula & Lundberg, 2014). The limitations of the existing research, the reservation with respect to transferring insights from one jurisdiction to another, the lack of data for the Swiss context and the complexity of the regulatory scenarios significantly curtail our ability to estimate the potential changes.

However, as outlined in the beginning of the chapter, the concept of these scenarios is not to accurately estimate what the effect of a particular form of regulation is, but rather to create stylized scenarios to provide some insight into the economic working mechanisms of regulatory changes. For this purpose, I have decided to include a total price elasticity variable based on the combined approach by Kilmer et al. (2010). However, it is important to bear in mind, that price elasticities are a concept that depends on a number of influencing factors that differ across countries and product. Typically cited influence factors are availability and price of substitutes, the price in relation to consumer income, complementarity between goods as well as the timeframe involved in the comparison (University of Minnesota Libraries Publishing, 2016).

Figure 23: Disposable income of selected European countries relative to typical marijuana retail prices [74]



One of these factors, the price in relation to consumer income is shown in Figure 24 where I have contrasted adjusted gross disposable income of households per capita for a number of selected European countries expressed in purchasing power standard per inhabitant with the average share of disposable income necessary to finance the annual consumption amount of a very frequent marijuana consumer (based on Swiss consumption patterns for comparison). The axis on the right represents both percentage values and typical retail prices/g expressed in 2015 USD.

[74] Data taken from (Eurostat, 2021; UNODC, 2017). The disposable income data was calculated as a 3 year average from 2016-2018, the estimated retail price data for marijuana in Switzerland (see chapter 4) was converted using average 2015 USD/CHF exchange rates (macrotrends.net, 2021) in order to be comparable to price data from the other countries.

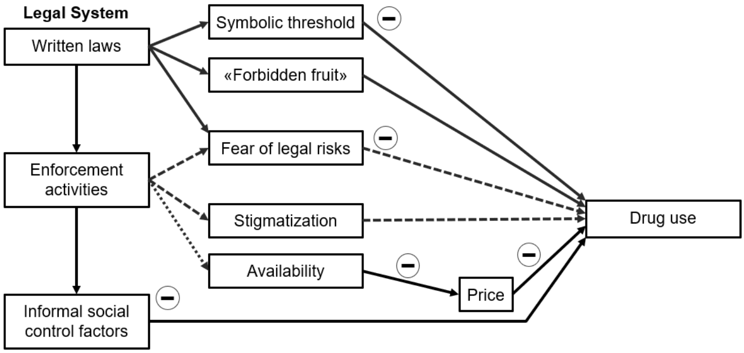
The graph shows, that Switzerland is one of the countries listed with the highest affordability of cannabis in Europe since the average disposable income is comparably high (Eurostat, 2021; Federal Statistical Office, 2021c) and the cost for cannabis relatively low. Based on this data and on the findings from Gallet (2014), I have reduced the estimate for total elasticity of demand to -0.35 to compensate for the smaller financial burden of cannabis purchases compared to other countries[75]. This means I assume an inelastic elasticity of demand where changes in price lead to a disproportionally smaller change in demand. This elasticity is applied to the assumed price differential between the status quo and each of the regulatory scenarios.

5.1.5.2 Non-price effects

The potential change in prices for cannabis products, however, is not the only source of effects on demand. On the contrary, both academic literature as well as our interviews with industry experts suggest, that so-called non-price effects could potentially play a larger role, than changes to the retail price and/or production costs. However, due to the nature of the effects (see Figure 25), they might not materialize in the short run (Vogel et al., 2019). This could be one explanation, why the empirical evidence on non-price effects is slim.

[75] It is important to note, that the retail price changes in some of the regulatory scenarios are rather large (-90% compared to the status quo). Since most quantitatively derived demand elasticities are derived for narrow bands of price changes, these measures are arguably a crude tool for this kind of estimation. See Scollo & Bayly (2020) for an extensive discussion of this topic.

Figure 24: Non-price-effects on drug use[76]



The legal system's influence on cannabis use. Red lines indicate links removed or weakened (dottet line) by legalization; broken lines indicate links weakened by decriminalization. Links are assumed to be positive unless indicated otherwise.

Pacula et al. (2009), based on U.S. Data for example "*suggest that a 10 percent decrease in the perceived harm of marijuana would generate a 28.7 percent increase in annual prevalence of marijuana use among youth*" relating to the symbolic threshold of using cannabis. Other authors suggest, that a legalisation would significantly decrease the attractiveness of cannabis consumption as an emancipation ritual for teenagers and young adults, lending weight to the "forbidden fruit" argument (Cattacin, 2020). Seminal work on the conceptional framework of non-price effects on drug use was conducted by MacCoun (1993, 2010) and has been discussed extensively (Borodovsky et al., 2020; Durak, 2018; Fischer, Daldegan-Bueno, et al., 2020). In short, the non-price effects discussed here are decision factors for cannabis (or other drugs) consumption that are not rooted in monetary causes of supply and demand, but influence decision making on a different level (see Figure 25). While these effects individually are hard to capture and are dependent on the actual cultural and legal context, there is some empirical evidence on the overall non-price effects in different jurisdictions around the world that have changed regulation in the past.

76 Reproduced and adapted from MacCoun (1993, 2010).

MacCoun (2010) summarises the literature on some reference cases: countries and jurisdictions that have depenalised cannabis possession (e.g. some U.S. states, the Netherlands, Portugal, some Australian states), the decriminalisation of home cultivation for non-commercial purposes (Alaska and South Australia) as well as the Dutch coffeeshop experience. For the depenalisation cases he finds that "*depenalization has either no or very small effects on the prevalence of cannabis use*" (p. 2) and that "*depenalization has little or no impact on the operation of forbidden fruit effects, price effects, or availability effects*" (p. 3). Overall, he concludes that the different reference cases "*suggest that the "non-price" impact on consumption might be on the order of a 35 percent increase in past-month use. Estimates in the range of 5 to 50 percent seem plausible; the available evidence provides no basis for anticipating non-price effects larger than 50 percent*" (p. 8).

The summary of MacCoun (2010) is in line with research on more recent examples. For Massachusetts (decriminalized in 2008), Connecticut (2011), Rhode Island (2013), Vermont (2013), and Maryland (2014) for which Grucza et al. (2018) find:

> «We did not observe any increase in cannabis use in any of the five states we examined, with follow-up times ranging from one to seven years. We did not find evidence for differential effects by age, nor did we find evidence for pre-implementation increases or delayed effects on cannabis use". *(p. 12)*

A similar lack of evidence was found for the European context by Vuolo (2013) who analysed a Sample of 15,191 respondents in the EU-15 countries in 2002 and 2004 and concludes "*among the strongest and most consistent findings, eliminating punishments for possession for personal use is not associated with higher drug use*". (p. 149)

In the case of Australia J. Williams & Bretteville-Jensen (2014) summarise the results:

> "While we find no evidence of any long run effect, we do find that for the first five years following decriminalization, those who start using cannabis tend to do so at an earlier age than would otherwise have been the case.

> There is also a small net increase in the proportion of the population who ever use cannabis in the first five years after the introduction of decriminalization." (p. 31)

While the effects of depenalisation on consumption appear to be weak to non-existent, this does not necessarily hold true for scenarios of comprehensive legalisation. Since other aspects, such as the development of social norms, availability and the fear of legal risks would be much more affected as in the case of depenalisation. However, based on the available evidence from jurisdictions around the world, the impact of legalisation regulations on cannabis consumption is inconclusive (Caulkins et al., 2018; Hall & Lynskey, 2020; Junta Nacional de Drogas (JND), 2019; Laqueur et al., 2020; Mahamad et al., 2020; Smart et al., 2017; Smart & Pacula, 2019). So far, there is no comprehensive indication, that changes in regulation significantly impact cannabis consumption prevalence, which is in line with older research on the topic (Reuband, 1998) who analysed the impact off regulatory regimes on cannabis prevalence and found no connection. Similar results are found from a medical perspective by Degenhardt et al. (2008) who analysed epidemiological data on drugs using the World Health Organization's (WHO) World Mental Health (WMH) initiative. Using data from more than 85'000 household surveys in 17 countries they find "*(…) Clearly by itself, a punitive policy towards possession and use accounts for limited variation in nation-level rates of illegal drug use*" (p. 1062).

However, given the limitations in the available longitudinal data on the topic (Hammond et al., 2020; Smart & Pacula, 2019) as well as the recency of the regulatory changes and the difficulty to distinguish between secular trends and regulatory impact, it is simply too early to tell. Because there is no conclusive evidence on the potential impact of non-price effects on cannabis consumption in a legal scenario, the regulatory scenarios are not adjusted for such.

5.1.6 Non-market effects police, jurisprudence, and court enforcement:

The effects of the regulatory scenarios that I estimate in this chapter extend beyond the market and affect other segments of the cannabis system too. How regulation affects the economic activity in the various segments depends significantly on the exact form of regulation applied and the way this regulation is actually enforced. Just how strongly the two can diverge, has been shown by Zobel et al. (2017b) for the example of police work. In their report they investigated the implementation and effect of the revised narcotics law dated October 1st, 2013. One of the provisions of this change was a form of decriminalisation. The concept is, that adult consumers can be punished with a spot fine of 100 CHF for consumption of less than 10 gram of cannabis without a criminal record and without a police citation ("Ordnungsbussenverfahren, OBV") (ibid., Fedlex, 2020). They find:

> "National indicators only partially show the real picture. Only by looking at cantonal data it becomes obvious, that some cantons barely apply the OBV, while others appear to apply the OBV in addition to the normal procedure and again others apply the OBV very thoroughly. (…) All investigations presented in this report seem to support the fact that there seems to be a very heterogenous treatment of cannabis consumers across cantons."[77]

The federal political system in Switzerland leads to a situation where narcotics law is set on the national level, but the policing of said laws and the court proceedings (on the lower court levels) is in the responsibility of the cantons. This means, that the actual effect of any given change in the legal treatment of cannabis related issues can take a variety of different forms and differ from canton to canton. However, for the purpose of this estimation I will forego this issue and assume a homogenous effect of

[77] Authors translation based on Zobel et al. (2017b, p. 7-8).

regulatory changes on both police, jurisprudence, and court enforcement.

The central limitation with reference to the estimation of non-market effects (police, jurisprudence, and court enforcement in particular) in different regulatory circumstances is the available data for the estimation. This relates to both, the available domestic data, as well as comparable reference data in other jurisdictions that are sufficiently comparable and have gone through a regulatory change that is similar. The analysis of the literature on the topic of non-market effects revealed a number of prohibitive methodological and data issues [78] when trying to compare non-market effects of regulatory changes for cannabis worldwide. For this reason, I have decided to simplify the estimation by relying solely on domestic data sources and disregard the initial idea of drawing on international references.

[78] These include, amongst others, wide differences in the initial legal situation and policing strategy, differences in legal systems, switches in policing strategies pre/post regulatory change, incomparable or inexistent (substance specific) data pre/post regulatory, differences in the temporal dynamic of the regulatory process, de-jure and de-facto regulation and differences in secular consumption trends of both cannabis and other substances.

Table 30: Adjustment factors for police citations by type of offense

	Status Quo	CSC	High-Regulation	Free-Market
Spot fines and Misdemeanours	37,259	-100%	-100%	-100%
Minor Production and Possession	4,792	-100%	-100%	-100%
Minor Trade and Import	4,675	-59%	-100%	-100%
Minor Export	17	3%	-4%	27%
Minor Transit	44	0%	0%	0%
Major Production and Possession	158	-59%	-100%	-100%
Major Trade and Import	189	-59%	-100%	-100%
Major Export	1	3%	-4%	27%
Major Transit	-	0%	0%	0%

For the estimation of the effects on policing activity I have adjusted the number of police citations based on the regulatory assumption I made for each scenario with respect to production, possession, consumption, trade, and import/export/transit. However, it is important to keep in mind, that the combination of regulatory assumptions and the specificity of the categories for police citations is not sufficiently precise to adequately estimate these effects. The methodology applied is thus a simplified estimation, rests on expert input and interpretation of the data and on the assumption, that all other factors stay equal (e.g. there are no changes in policing intensity and/or focus).[79]

For the CSC scenario, where the coexistence of a legal and illegal market is assumed, I have adjusted the police citation based

[79] It would not be an unreasonable assumption to politically decide to strengthen policing intensity on illicit market activities on different levels to support a swift transition to a different regulatory scenario.

on the scenario assumptions as follows: activities leading to spot fines, misdemeanours, as well as minor cases of possession and production are legal and thus are set to 0, minor cases of trade and import are reduced by the share of reduction in the quantity traded on the illegal market (-59%), minor cases of exports are increased by the percentage increase in total consumption (3%). Major cases of production, possession, trade and import are reduced by the share of reduction in the quantity traded on the illegal market and major cases of export are again increased by the percentage increase in total consumption. Transit cases are assumed to be unaffected by domestic regulation. For the High-Regulation and Free-Market scenarios the case lies different. The only activities illegal in these scenarios are the import, export and transit of cannabis. Since I assume a completely legal market satiated by domestic production, imports are assumed to be non-existent too. Exports on the other hand are scaled again based on the development of total consumption in comparison to the status quo and transit cases remain unaffected by domestic regulation.

Chapter 3.11 extensively discusses the data limitation regarding the estimation for both jurisprudence and court enforcement. Since the data available for these two segments is not sufficiently detailed for further analysis, it is necessary to approximate the changes for both segments using assumptions. When considering which form of sentencing applies to which form of offense, it is clear, that the more severe the offense, the more severe the punishment. While spot fines are applied only to consumption cases including less than 10 grams, misdemeanours often end in fines. Isolated and non-repetitive and isolated light cases are usually punished by monetary penalties. Only serious cases or repetitive cases including larger quantities sometimes end in jail sentences.[80] Since both jurisprudence and court enforcement are directly affected by changes in the legality of the offenses (see Table 30), as they do not need to handle these cases any longer, the economic effects of both segments need to be adjusted as well. Based on the

[80] Based on interviews with cantonal police forces.

qualitative input I received from cantonal police forces I adjust the penalties and fines by the total change in offenses, whereas jurisprudence is only adjusted by the change in light and serious cases. Jail sentences on the other hand are adjusted only for the change in serious cases (see Chapter 3.11).

It needs to be iterated, that these are stylized assumptions. Each assumption can and should be challenged and adapted in the future if more information becomes available.

5.1.7 Non-market effects healthcare

When following the international discussion on cannabis regulation, there are two hypothesis that are often heard with respect to healthcare. The first hypothesis is that decriminalization, depenalisation or legalisation could lead to increased and/or more intensive use and would in extension increase healthcare costs to treat adverse health outcomes (see chapter 3.2). The second hypothesis is that decriminalisation, depenalisation or legalisation would increase healthcare utilization as it would lower the threshold to seek professional help (due to a decrease in the social stigma or a decrease in fear of legal repercussions) and improve access and availability of consumption specific healthcare providers. Since some jurisdictions around the world have changed their regulatory approach to cannabis in recent years, there is some empirical evidence available on the effects of regulatory change on the healthcare sector.

Delling et al. (2019) for example have analysed 16m hospital admissions in Colorado from 2010 to 2014. Since recreational cannabis use was legalised from private production in December 2010 and from commercial sources in January 2014, the effects on healthcare utilisation and diagnoses was compared to a control group of two other states which did not enact a legalisation (NY, OK).

> "Legalisation of recreational cannabis was associated with more cannabis abuse and minimal effects on overall healthcare utilisation. Changes in specific medical diagnoses post-legalisation reflected previously published substantial or moderate evidence on the health effects of cannabis, including an increase in motor vehicle accidents, alcohol abuse, overdose injury and a decrease of chronic pain admissions. The increased frequency of hospitalisations for cannabis abuse in CO helps to validate the concept that legalisation would result in greater use" *(p. 6)*.

The findings are in line with Vigil et al., (2018) who analysed data from the national poison data system for Colorado and find "*legalization did not noticeably impact marijuana use rates, but has increased healthcare encounters with mention of marijuana*".

A more comprehensive approach using difference-in-differences estimates was conducted by A. R. Williams et al. (2017) who analysed data from the US National Survey of Drug Use and Health (NSDUH) from 2004-2013 to analyse changes in cannabis use and in prevalence of cannabis use disorder for states with medical marijuana laws (MMLs) and states with non-medical MML programs. They conclude:

> "Adults 26+ years of age living in states with non-medical MML programs increased past-month marijuana use 1.46% (from 4.13 to 6.59%, P = 0.01), skewing towards greater heavy marijuana by 2.36% (from 14.94 to 17.30,P = 0.09) after MMLs were enacted. However, no associated increase in the prevalence of cannabis use disorder was found during the study period. Our findings do not show increases in prevalence of marijuana use among adults in states with medicalized MML programs. Additionally, there were no increases in adolescent or young adult marijuana outcomes following MML passage, irrespective of program type" (p. 1).

The evidence from Colorado and other U.S. states suggests that the introduction of non-medical MMLs has had no statistically significant impact on the rates of cannabis use amongst high school students, young adults (18-26) and a small effect for older adults (26+) (Ghosh et al., 2016, 2017; Vigil et al., 2018; A. R. Williams et al., 2017). This is in-line with findings on the effects of MMLs which also show limited or non-existent effects on adolescent marijuana use (Cerdá et al., 2012; Harper et al., 2012; Hasin et al., 2015; Lynne-Landsman et al., 2013). Mixed preliminary evidence is seen in Canada, where Cannabis was commercially legalised in October 2018. Turna et al. (2021) report an increase in users who did not use cannabis prior to legalisation and a decrease in users who did use cannabis prior to legalisation.

The preliminary research for the U.S. also shows an increase in healthcare utilisation, emergency department visits related to cannabis codes (especially among out-of-state residents), poison centre calls with marijuana reference and fatal car crashes with positive driver tests for cannabinoids (Aydelotte et al., 2019; Calcaterra et al., 2019; J. M. Davis et al., 2016; Delling et al., 2019; Durand & Chao, 2017; Ghosh et al., 2017; H. S. Kim et al., 2016; Wang et al., 2017, 2018). A comprehensive summary of the (limited) evidence available to date on the relation between regulatory change and cannabis use and cannabis use disorders for the USA was conducted by (Hall & Lynskey, 2020; Leung et al., 2018). Since cannabis usage has largely been unaffected by regulatory change but healthcare outcomes have not, this lends some evidence to the second hypothesis, that alternative regulation might lower the threshold to seek professional help and that it leads to an improved access to patients seeking and needing care.

In summary, the empirical evidence from other jurisdictions so far suggests different channels how regulatory change can affect the economic effects in the healthcare system:

- By an increase in cannabis use prevalence
- By a more frequent or more intensive consumption pattern
- By an earlier age-of-onset
- By the consumption of more potent cannabis products

- By a heightened population sensibility for adverse health effects related to cannabis consumption
- By a decreased stigma associated with cannabis consumption and cannabis related health effects
- By a decrease in fear of legal repercussions
- By an increase in accessibility of healthcare providers for acute and chronic health effects of cannabis consumption
- By an increase in sensibility of existing healthcare providers for cannabis consumption related health outcomes

Regarding a potential estimation of these effects, the channels can broadly be grouped into two categories. One category contains changes in consumption (prevalence, pattern, intensity, etc.), the other group contains non-consumption related changes (stigma, legal repercussions, healthcare utilization, etc.). A change in regulation will most likely affect both categories and there are interdependencies between the two groups that would need to be accounted for. However, the existing evidence from other jurisdictions is limited, partially inconclusive and not necessarily transferable to the Swiss healthcare context. In addition, the non-consumption related effects are highly dependent on both the initial situation before a regulatory change, the actual regulation and other questions pertaining to taxation, funding and the reaction of healthcare providers.

For both categories, the available domestic data as well as the empirical literature do not provide a sufficient basis for a sensible estimation of potential effects. For this reason, a detailed estimation of healthcare effects is excluded from the estimation of economic effects at this stage. Instead healthcare costs are scaled in relation to the change in total consumption quantity in each scenario as a simplified stylized approximation. Future research should address this topic in more depth once more data becomes available.

5.1.8 Considerations concerning international developments:

Another aspect precluded in our simulations are the international developments with respect to cannabis regulation. All scenarios and all assumptions are based on the premise, that there are no significant changes in other countries regulation of cannabis. This is important to note, as potential changes internationally could have at different effects on Switzerland.

- If cannabis production and export were to become legal in other jurisdictions (e.g. along the most common European supply routes: northern Africa, the Balkans, or the middle east) and imports were to become legal in Switzerland there would be significant pressure on wholesale and retail prices as it would be near impossible for the swiss agricultural sector to compete with other countries given the comparatively high level of production costs in Switzerland. However, this topic is primarily a hypothetical discussion. The issue of agricultural production costs in comparison to other countries applies to most agricultural products and has been addressed on a national level by various swiss agricultural policies that both directly subsidise domestic producers as well as sets quotas and tariffs on imports from other countries (Federal Office for Agriculture FOAG, 2020a; Gentile, 2016; Gray et al., 2017).
- If cannabis purchases, possession and consumption for non-residents were to be permitted and regulation of cannabis in adjacent countries and other countries with strong tourism connections to Switzerland would not change, there would likely be four effects associated:
- An increase in demand from tourists in Switzerland
- An increase in (illegal) private exports from Switzerland (depending on regulations concerning purchasable quantities)
- An increase in healthcare interventions for international visitors

- The development of cannabis tourism (Korf, 2019; van Ooyen-Houben et al., 2016)
- If industrial scale production in Switzerland were legal, there would likely be an increase in (illegal) wholesale exports to other countries. This assumption is based on both developments in the Netherlands (Belackova et al., 2015; Kinderen & Rombouts, 2018; Korf, 2019) as well as on first-hand experience in Switzerland between 2000-2005 when cannabis produced in Switzerland was increasingly exported to the Netherlands on a wholesale level (Sven Schendekehl, personal communication, 4 June 2021).
- Potential changes in international regulation might affect bi- or multilateral treatments that Switzerland has signed with other countries. These treaties can affect different regulatory aspects. Taxation can be taken as an example. In the EU, illegal activities are not being levied by VAT. This has led to the situation, where coffeeshops in the Netherlands (until 2007) received substantial VAT refunds "*because input-VAT exceeded output-VAT or output-VAT was zero*" (Van den Ende, 2016, p. 539) as they were not allowed to add VAT to cannabis related revenue, but were allowed to deduct VAT on their intermediary inputs.

While there are many countries in Europe and worldwide, that currently discuss changes to their regulatory regime with respect to cannabis, it remains unclear, what the outcome of these processes will be. In addition, both the relevance and the extent of the outlined impacts depends not only on developments abroad, but also on future regulatory details in Switzerland. For these reasons I have excluded the estimation of potential changes in international regulation for the purpose of this simulation.

5.2 CSC SCENARIO: NON-COMMERCIAL LEGALISATION OF COOPERATIVE PRODUCTION IN THE FORM OF CANNABIS SOCIAL CLUBS

Cannabis social clubs (CSCs) are privately organized clubs or organisations that produce and trade/distribute cannabis to its adult members. Since these clubs usually do not operate with a commercial motive (in the sense that they have a profit or growth motive) and restrict their activities to the members of the clubs, it is a form of cannabis provision without a commercial background. Following the structural guidelines set out in the beginning of the chapter, CSCs fall within the third and fourth category of Figure 19. The central defining element for this scenario is the legality of consumption and ownership for adults, as well as production and distribution/trade with the absence of a commercial motive.

CSCs have sprung up in several countries around the world as a reaction to explicit or implicit regulation and policing of cannabis production. Some well-known countries who made first-hand experiences with CSCs are Belgium, Spain, and Uruguay, even though there are a number of other countries which also have CSCs (Pardal et al., 2020). In Switzerland, forms of CSCs have also been part of the public discussion, but have not yet materialised (Cattacin & Philibert, 2014).

However, there are significant differences between the different forms of CSCs that exist in different jurisdictions in terms of how and why they came into existence, how or if they are regulated, how they operate and which alternative sources of cannabis exist. In Spain for example CSCs largely operate in a legal grey area. While there is no explicit regulation with regard to founding and operating a CSC, they are often times registered associations (Alonso, 2011, p. 3), have contract staff with social security payments and pay taxes (ibid, p. 5). It is a situation that stems primarily from the customary interpretation of case-law related to cannabis consumption, ownership, and production (ibid, p. 1-2). For this reason CSCs have set up industry associations and political interest groups to provide guidance and push for comprehensive and transparent regulation of CSCs (Dinafem Seeds, n.d.; European Coalition for Just and Effective Drug Policies (ENCOD), 2020). In Belgium, the legal situation is also unclear, both in terms of national regulation, as well as in relationship to international treaties that Belgium has signed (Decorte, 2015; Pardal, 2016). CSCs operate in a legal grey zone that is primarily based on domestic legislation with respect to personal use/ownership. In Uruguay on the contrary, CSCs are explicitly regulated and constitute one of three (mutually exclusive) ways of legally obtaining cannabis (the other two being growing your own or purchasing it from dispensaries) (Cerdá & Kilmer, 2017).

CSCs represent a particular form of regulation (or non-regulation) based on a more general concept. The concept is to regulate cannabis supply, ownership, and consumption from a non-commercial perspective. By this I mean an approach that refrains from using profit-seeking private-sector entities and instead relies on alternative organisational forms for production and distribution. Privately organized clubs or collective cultivation cooperations are one way of doing so, governmental licensing for production and/or licensing (e.g. through dispensaries) are alternative forms, with similar working mechanisms.

5.2.1 Regulatory variables and assumptions

In comparison to the status quo, this regulatory scenario changes the following regulatory variables about the cannabis market in Switzerland:

- **Retail Market**: The scenario assumes the co-existence of three different modes of obtaining cannabis. The first mode is legally regulated CSCs, the second is the legal production[81]

[81] While the parallel regulation of cooperative production and homegrowing is often assumed to go hand-in-hand, justified by an intrinsic logic of regulating the same in the same way, there are also valid arguments against doing

of cannabis for personal consumption out-of-sight at home (homegrowing) and the third is the illegal market.

- o **Club modalities**: I assume the following operating parameters for clubs
- o limit on member age (18 years)
- o limit on member residency (sale only to Swiss residents)
- o limits on distribution to personal use quantities[82]
- o Semi-professional production capacity for both marijuana and resin
- o Contractually employed personnel for production, distribution, and management
- o Members pay for their cannabis at sub-market rates (7 CHF for marijuana, 8 CHF for resin) to cover both club costs as well as contribute to mitigate external costs. Another reason for a sub-market rate significantly above production costs is to disincentive illegal market purchases and create a barrier to spill over effects (youth prevention).
- o Cannabis can be consumed at the club or taken home for private consumption.
- o The revenue is taxed at 60%[83], the remaining 40% can be used by the club to cover costs and offer additional services

so (Eykelbosh & Steiner, 2018; Fischer, 2017; Fischer & Daldegan-Bueno, 2020).

[82] I assume a generous but limited definition of personal consumption amounts individual to each person's consumption behaviour. This is to ensure, that there is no motivation for members to supplement their consumption with illegal market products and at the same time prevent spill over effects where club members redistribute or sell a share of their club-cannabis to people outside the club.

[83] The threshold of 60% is primarily based on assumed production costs. A similar taxation scheme is applied for the taxation of casinos in Switzerland where gross gaming revenue is levied between 40-80% for terrestrial casinos to allow for adequate capital returns based on cost-effective operations. (Eidgenössische Spielbankenkommission, 2020).

to members such as regular check-ups, counselling, or research (D. D. Walker, 2017).

- **Cannabis accessibility**: It is assumed that there is widespread availability of CSCs to satiate market demand (Wouters et al., 2010). Accessibility it not assumed to be a limiting factor for demand. With widespread availability, a significant market reach for CSCs is assumed and a 75%shift of the quantity consumed by 30-day prevalence consumers and consumers not reached by surveys to the legal market provided by CSCs. The remaining 25% as well as consumers with 12-month prevalence but no 30-day prevalence continue to source their cannabis on the illicit market which is assumed to coexist with an identical structure to the status quo.
- **Marketing**: There is a far-reaching ban on any marketing activity by the CSCs both for memberships and products.
- **Domestic production**: The domestic production for commercial purposes remains illegal. Homegrowing out of sight is permitted for personal consumption and without commercial intent.
- **Policing**: There is no change in policing intensity for illegal market activity.
- **Import and export**: The import, export and wholesale trade of cannabis is prohibited, just as in the status quo.
- **Taxation**: The clubs are assumed to be for the public welfare and thus are, except for the revenue tax, tax exempt with respect to VAT, profit or capital taxes.

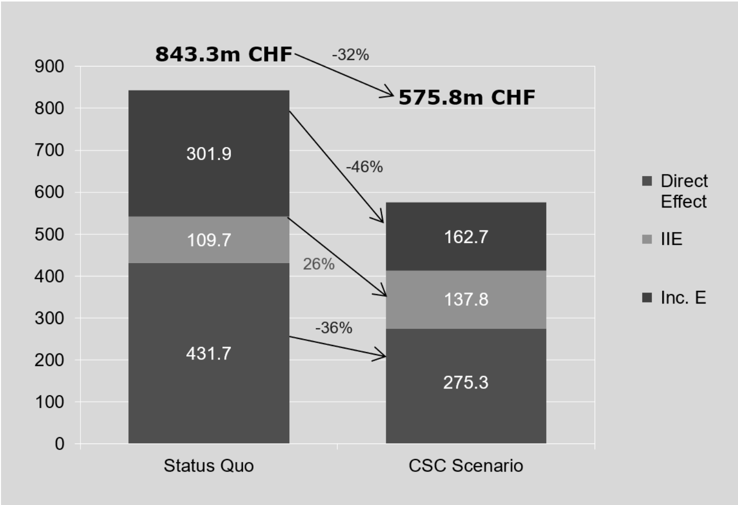
5.2.2 Results

The results of the scenario simulation in terms of total gross output for the market segment are shown in Figure 5. In comparisons to the status quo total gross output decreases from 843m CHF to 576m CHF. When looking at the individual components, we see an increase in the IIE (110m CHF to 138m CHF, +26%), a decrease in the income effect (302 CHF to 163m CHF, -46%) and a decrease in direct effects (432 CHF to 275m CHF, -36%). It is important to note, that the applied product taxes are neither part of GO nor GVA.

The results reflect several different effects. One striking result might be the significant reduction in the income effect. This is caused primarily through the shifting of a significant share of demand from the illegal market into the legal setting of the CSC. In the status quo, a significant share of the economic effects accrued as GVA from the production and import of cannabis. This GVA primarily represents profits of producers, importers, wholesale- and retail traders. In a legal setting, this GVA would represent different economic components, interest on debt capital, dividends on equity capital, wages, taxes, social security contributions, profits, etc. However, as the operations along the cannabis supply chain are illegal, there are a number of these components, that do not exist (at least formally): cannabis producers do generally not pay social security or taxes. Regardless, it can safely be assumed, that a significant share of GVA is used as a wage-equivalent income for actors along the supply chain and thus is used for consumption and savings. It can further be assumed, that capital costs are also paid, at least informally, for the people organising and financing production and trade operations. I have conservatively estimated a share of 59% of GVA[84] as wage equivalent incomes in the status quo. These "incomes" are in returned used for average household consumption patterns and are one of the sources of the income effect.

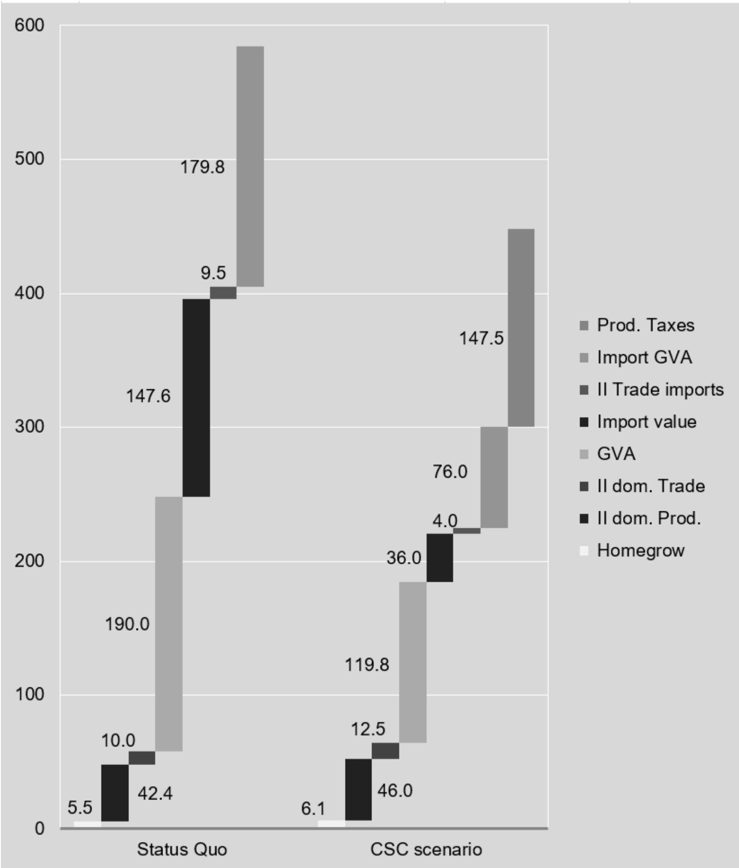
[84] Which corresponds to the average wage share of GVA for the Swiss economy (Federal Statistical Office, 2020d).

Figure 25: Estimated change in total gross output for the cannabis market status quo vs. CSC scenario (in m CHF)



In the CSC scenario, this structure starts to shift. With a significant share of demand now being satisfied through the legal structure of a CSC with slightly lower "retail" prices than in the illicit market, a more professional production and thus lower production costs and formal wages, labour productivity measured in GVA goes down. However since labour productivity is defined as GVA per FTE, it is obvious that this productivity is rather high – even compared to legal sectors of the economy (Lalam, 2017) – in the illicit market, as it is able to generate immense profits with comparably low labour input (see Table 27). In the CSC scenario, this is different. The CSCs are able to supply the demand with a more cost-efficient production structure which would c.p. lead to higher margins. But since we apply comparably lower retail prices through regulation and additionally tax the generated revenue at 60%, a share of the previous illegally generated GVA now constitutes product tax revenue rather than illegal GVA (see Figure 27). The remaining 40% of revenue is used to cover production costs, distribution, club operations and member activities (which could be specified by regulation, such as research projects, regular counselling/interviews, product development, consumption advice, etc.).

Figure 26: Cannabis expenditure of the market segment; status quo vs. CSC scenario (in m CHF)



While we assume consumption to increase slightly to the decrease in price (see the discussion on price elasticity in chapter 6), this increase is too small, to substitute the total decrease in expenditure caused by the decrease in retail price, hence we see a net decrease in total expenditure.

The third effect is the repatriation of economic effects caused by the demand shift from the illicit market to the CSCs. In the status quo, one third of the marijuana supply and the entirety of the resin supply is imported illegally from abroad (see Figure 27). What this means with respect to the economic effects, is that a significant share of the cannabis does not actually cause effects in Switzerland but flows into other countries in the form of import value. The remaining effects in Switzerland are thus limited to the trade activity. In the CSC scenario there are two changes to this situation. On the one hand, the shift from the illicit market to the CSCs means that a share of cannabis that was previously imported into Switzerland is now being produced domestically. This is reflected by the decrease in import value and the net increase in production costs in Figure 27 even though the actual production costs per gram are less than in the status quo, the total amount produced is higher, due to the repatriation effect. Phrased differently this means that a share of economic activity that previously happened illegally and outside of Switzerland is now happening domestically and legally (and can be taxed, too). This repatriation effect has two components, one pertains to marijuana, the other to resin products which are now being produced at scale from production leftovers from marijuana production. Since resin was previously assumed to be completely imported from abroad, this newly created domestic production capacity sold at lower than illicit-market-prices creates competition for imported products and is assumed to take over a substantial share of demand previously provided by illegal imports.

Another effect, which I did not explicitly quantify, but which will likely to occur with decreases in retail prices is a budgetary shift. If consumers spend less on cannabis products, they are likely to spend more on other goods.

> "Especially for heavy users, a price decline acts almost like an increase in income because it allows the person to afford the same quantities of everything he or she had been

> buying before (marijuana and other goods), plus some more. Based on our analysis of NSDUH, we estimate that the median gram of marijuana is consumed by someone who spends about 5 percent of income on marijuana. So, for a typical user, a 70-percent price decline would feel like a 3.5-percent increase in income perhaps leading to an extra ("income elasticity") bump up of 3.5 percent in use" (Kilmer et al., 2010, p. 23).

This consumption substitution effect is directly tied to a potential retail price decrease and is thus largest in the High-Regulation scenario (direct effect of the market segment 93m CHF) and the Free-Market scenario (direct effect of the market segment 54m CHF). The lower the market revenue for cannabis products given stable demand the higher the disposable income for other goods and services.

With the adjustment of the non-market segments following the changes to court enforcement, jurisprudence, police and healthcare I made for the CSC scenario (see chapter 5.1) the gross output share of the market segment increased to about 89% compared to 84% in the status quo.

Table 31 presents the overall results for the economic impact estimation for the CSC scenario. The overall tax revenue generated in this scenario amounts to about 166m CHF. The by far largest share of this is generated by the product taxation of the CSCs revenue (148m CHF, 89%). Other taxes generated by market activity (income, VAT, product taxes) add another 14m (8%). The remaining taxes are generated by economic activity in the other segments of the cannabis system which drop considerably based on our assumptions (see chapter 5.1).

Table 31: Results economic effects cannabis system CSC scenario

	Gross Output in m CHF	Gross value added in m CHF	Employment in FTE[1]
Direct effects	**313**	**223**	**1,417**
Court enforcement	5.0	4.4	15
Jurisprudence	2.1	1.8	9
Police	6.7	4.7	32
Healthcare	24.0	16.4	132
Market	275.3	195.8	1,228
Indirect effects	**325.6**	**161.8**	**1,244**
Income effect	182	98	631
Court enforcement	*1.81*	*1.0*	*6*
Jurisprudence	*1.51*	*0.8*	*5*
Police	*3.95*	*2.1*	*14*
Healthcare	*12.3*	*6.5*	*42*
Market	*163*	*87*	*563*
Intermediate input effect	143	64	613
Court enforcement	*1.8*	*0.9*	*6*
Jurisprudence	*0.5*	*0.2*	*2*
Police	*3.3*	*1.5*	*11*
Healthcare	*10.9*	*4.6*	*26*
Market	*137.8*	*61.7*	*596*
Total effects dir. + indir.	**650**	**390**	**2,687**
Court enforcement	9.4	6.3	27
Jurisprudence	4.1	2.8	16
Police	14.0	8.3	57
Healthcare	47.2	27.5	201
Market	576	345	2,387
Taxes, penalties and fines	**165.7**		
Court enforcement	0.5	(0.27%)	
Jurisprudence	0.3	(0.16%)	
Police	0.8	(0.51%)	
Healthcare	2.1	(1.29%)	
Market other.	13.8	(8.35%)	
Market prod.	147.5	(89.03%)	
Penalties and fines	0.7	(0.39%)	

1) Full time equivalents

As a point of reference, the federal customs administration (FCA) provides data on both the tax revenue associated with alcohol and tobacco products. Alcohol consumption has been steadily declining in Switzerland between 2001-2020 from 9.2l of pure alcohol in 2001 to 7.6l in 2020. The average consumption of

Alcohol in Switzerland for 2016 as an example was about 33.8l of wine, 1.7l of wine made of other fruits, 54.9l of beer and 3.6l of liquor and spirits. This corresponds to about 7.9l of pure alcohol (Federal Customs Administration FCA, 2021a). Alcohol is taxed at different rates per product and the liquor and spirits tax collected for 2016 amounts to 249.3m CHF of which 90% (224.4m CHF) go towards the pension, widow and disability insurance (AHV/IV) and 10% (24. 9m CHF) go toward the cantons who use these funds for activities primarily in prevention (53%), early detecting (16%), treatment (22%) and other activity (Federal Customs Administration FCA, 2017). In addition to the liquor and spirits tax, beer is taxed separately, and the tax revenue generated from beer amounted to about 113m CHF in 2016.

For tobacco, the tax revenue generated in 2020 was about 2.2.b CHF with slightly more than 9b cigarettes sold (Federal Customs Administration FCA, 2020b). The tobacco tax has been used as a regulatory tool for controlling consumption and has been fairly successful, given the decrease in smoking over the last decades (Chaloupka et al., 2011; Jacobson et al., 1997; N. Wilson & Thomson, 2005). Similar effects have been found for alcohol taxation (Wagenaar et al., 2009).

Based on the assumptions I have made for this scenario, the product tax revenue generated from the revenue tax for CSCs would be a little more than half of the tax revenue generated from liquor and spirits taxation.

When comparing this data, it is important to keep in mind, that the prevalence of consumption for the different substances is very different. The prevalence for alcohol consumption in the population older than 14 years is 85.9% compared to 25.3% for tobacco and 7.3% for cannabis (Gmel et al., 2017).

5.3 HIGH-REGULATION SCENARIO: COMMERCIAL LEGALISATION WITH HIGH TAXATION AND PUBLIC HEALTH-ORIENTED REGULATION

The High-Regulation scenario was created focusing on three key areas:

- a commercial organisational form for the production and trade of cannabis,
- a focus on public-health-oriented outcomes with respect to regulatory variables
- a limit on commercial profitability and a focus on public-health measures by applying a tax scheme similar to tobacco taxation in Switzerland.

This scenario is based on the initial discussions of cannabis regulation in Canada (Bear, 2017; Crépault et al., 2016; Hajizadeh, 2016), as well as the regulatory proposals currently under deliberation in New Zealand (Caulkins, 2018; Fischer, Daldegan-Bueno, et al., 2020; Fischer & Daldegan-Bueno, 2020; Rychert & Wilkins, 2020a; Wilkins, 2016). While the scenario uses a commercial model for the production and distribution of cannabis, economic success is not the main priority. Instead, the commercial model is used primarily for its efficient form of production and distribution, while at the same time, strong public-health oriented measures are used to control the market forces. One of the main design aspects of this scenario is the relatively high product tax based on both weight and value which allows the public authorities to internalise some of the societal externalities caused by cannabis consumption in Switzerland. The funds generated by thetaxation of cannabis can for example be used for addressing cannabis-related problems in healthcare, drug-counselling or prevention.

5.3.1 REGULATORY VARIABLES AND ASSUMPTIONS

In comparison to the status quo, this regulatory scenario changes the following regulatory variables about the cannabis market in Switzerland:

- **Retail Market**: I assume a fully displaced illicit market in the medium term and a demand completely met by legal means [85]. I assume a form of not-for-profit operating licenses (non-monopolies) for private sector entities selling to Swiss residents through specialised shops.
- Retail regulation:
- The age limit for legally purchasing, producing, and possessing cannabis is 18 years
- Only Swiss residents can legally purchase cannabis products
- There are purchase limits for personal use [86]
- Specific requirements with respect to packaging and labelling of product content
- Regulatory oversight and strict enforcement of regulatory provisions
- Production and trade:
- Professional production capacity for both marijuana and resin
- Requirements with respect to product purity, the use of pesticides and adulterants for product quality on a pharmacological level

[85] Based on experiences in other jurisdictions, this assumption is not unreasonable (Knudson & Miller, 2020).
[86] I assume a generous but limited definition of personal consumption amounts individual to each person's consumption behaviour. In the U.S., personal use amount is often defined as 1 ounce or 28.35 grams. This corresponds to the quantity used for about 140 joints (on average).

- Regulatory oversight by specified public body (e.g. Swissmedic)
- Legal employment for production, distribution, and management personnel
- **Cannabis accessibility**: It is assumed that there is general availability of cannabis to satiate market demand. Accessibility it assumed to be a minor limiting factor for demand (Wouters & Korf, 2009).
- **Marketing**: There is a far-reaching ban on any marketing activity with respect to cannabis products on production-, wholesale- and retail-level.
- **Domestic production**: The domestic production of cannabis is legal, but underlying regulatory constraints with respect to product quality, packaging, and sales channels. Homegrowing out of sight is permitted for personal consumption and without commercial intent.
- **Policing**: There is no change in policing intensity and focus for illegal activity such as tax evasion and smuggling.
- **Import and export**: The import and export of cannabis remains prohibited. Effects related to regulatory changes abroad are not addressed in this project.
- **Taxation**: Cannabis is taxed by the same concept as tobacco and CBD cannabis was taxed in Switzerland previously. I apply a tax based on both production weight and retail value. Marijuana is taxed at 4.800 CHF/kg and resin at 7.900 CHF/kg. Additionally, I apply a 50.7% (incl. VAT) value tax to achieve the assumed retail price of 10 CHF/g for Marijuana and 13 CHF/g for resin.

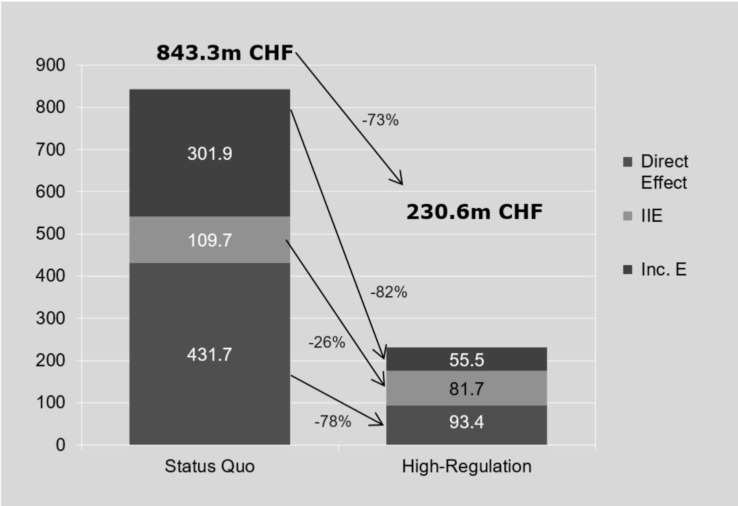
5.3.2 Results

The High-Regulation differs from both the CSC scenario and the status quo with respect to two factors. The first is the fact that I assume a regulated, commercial market with private sector firms providing domestic cannabis production and trade in specialised shops. The second change pertains to the legality of production and trade with commercial intent, which is assumed to be legal in this scenario to be coherent with a legal market. The only illegal activities are the import, export, and transit of cannabis. Since I assume a completely legal market satiated by domestic production, imports are assumed to be non-existent.[87] Exports offences are scaled based on the development of total consumption in comparison to the status quo and transit cases are assumed to remain unaffected by domestic regulation.

Figure 28 shows the results of the estimated economic effects for the market segment of the cannabis system (in terms of gross output). Total gross output drops by about 613m CHF. When looking at the individual components, the significant reduction in the income effect (302m to 56m CHF) is striking. As in the CSC scenario, this is largely explained by the fact that demand is now completely satisfied by commercial firms in the market with lower retail prices than in the illicit market, a more professional production and thus lower production costs and formal employees. The largest share of the income effect in the status quo is caused by artificially high margins in the illicit market. Since the same quantity is now produced by legally operating private sector actors with both lower production costs and significantly lower profit margins, the revenue that previously ended up as illegal incomes and profits is now captured by the tax scheme and thus is not part of gross output anymore.

[87] Simplified assumption; see discussion on grey market and tax evasion in the concluding remarks.

Figure 27: Estimated change in total gross output for the cannabis market status quo vs. High-Regulation scenario (in m CHF)



The transfer from GVA to tax revenue as well as the transfer of the other economic components is shown in detail in Figure 29 which shows the breakdown of cannabis expenditure between the status quo and the High-Regulation scenario.

The second effect which can be seen in Figure 29 is that the illegal import previously supplying the Swiss market is now completely displaced by domestic production of both marijuana and resin. While this is obviously a simplified assumption, it is an outcome that can be fostered by an increase in enforcement activity and penalties on illegal production and imports as well as by regulating the domestic market in a way that makes it more attractive to producers, retailers and consumers.

Figure 28: Cannabis expenditure of the market segment; status quo vs. High-Regulation scenario (in m CHF)

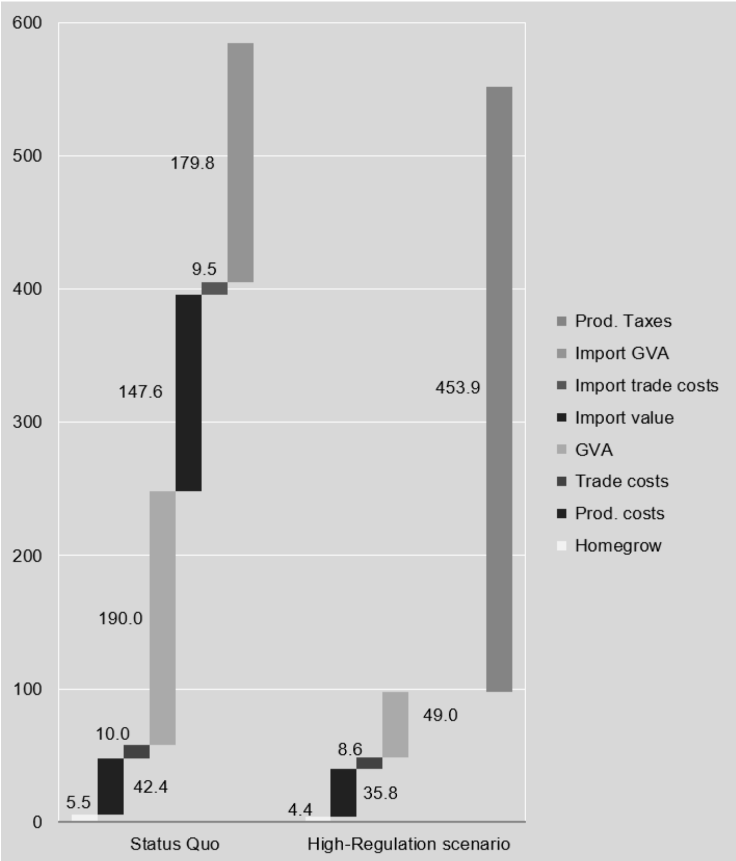


Table 32 shows the aggregated economic effects for the High-Regulation scenario for gross output, gross value added, employment effect and tax effect on the direct and indirect level. One obvious effect in this scenario is the reduction of economic effects associated with police forces, jurisprudence, and court enforcement. As most previously illegal activities are now legal (-99,4% of police filings), the economic effects associated with these activities are now not justified anymore and thus are not counted in the cannabis system. In terms of labour required this effect means a reduction of economic effect by about 240 FTEs (see Table 28 and Table 32). This does not mean, that the resources required for these activities previously just vanish. On the contrary, the freed-up resources of police forces, prosecutors and courts can be redirected to other causes, if necessary.

Table 32: Results economic effects cannabis system High-Regulation scenario

	Gross Output in m CHF	Gross value added in m CHF	Employment in FTE[1]
Direct effects	**116**	**65**	**433**
Court enforcement	0.05	0.03	0.12
Jurisprudence	0.06	0.05	0.26
Police	0.19	0.13	1
Healthcare	22.5	15.40	124
Market	93.4	49.0	308
Indirect effects	**149.0**	**69.0**	**596**
Income effect	67.2	35.9	233
Court enforcement	*0.01*	*0.01*	*0.05*
Jurisprudence	*0.04*	*0.02*	*0.15*
Police	*0.11*	*0.06*	*0.38*
Healthcare	*11.5*	*6.1*	*40*
Market	*55.5*	*29.7*	*192*
Intermediate input effect	81.8	33.2	363
Court enforcement	*0.01*	*0.01*	*0.05*
Jurisprudence	*0.01*	*0.01*	*0.04*
Police	*0.09*	*0.04*	*0.30*
Healthcare	*10.2*	*4.3*	*24*
Market	*81.7*	*33.1*	*363*
Total effects dir. + indir.	**275**	**138**	**1,053**
Court enforcement	0.07	0.05	0.2
Jurisprudence	0.11	0.08	0.4
Police	0.39	0.23	2
Healthcare	44.2	25.8	188
Market	230.6	111.8	863
Taxes, penalties and fines	**463.9**		
Court enforcement	0.00	(0%)	
Jurisprudence	0.01	(0%)	
Police	0.02	(0.01%)	
Healthcare	2.0	(0.43%)	
Market other.	8.0	(1.72%)	
Market prod.	453.85	(97.83%)	
Penalties and fines	0.02	(0%)	

1) Full time equivalents

Analysing the product tax effect of the High-Regulation scenario shows an increase to 464m CHF based on the applied weight/value tax scheme, as well as on the other tax effect of the market segment and the effects of the non-market segments. 98%

of the overall tax effect is caused by the product taxation of cannabis. Obviously, the applied tax scheme is highly stylized and needs to be interpreted as an upper boundary estimate. The tax rate assumed in this scenario are based on analogous retail prices compared to the current illicit market. From a public-health-perspective this might not be a sensible approach if one goal of a different regulatory approach is to displace the illicit market. It does show however, what the maximum[88] potential for taxation would be given the current market structure.

To better understand the context of the estimation it is worthwhile to compare it with the current taxation of tobacco in Switzerland. Two tobacco products can be taken as a comparison, cigarettes and finely chopped tobacco used for rolling individual cigarettes. Cigarettes are currently taxed at a weight rate of 118.32 CHF per 1.000 cigarettes (Federal Customs Administration FCA, 2020a). This corresponds to about 180 CHF/kg of tobacco when assuming an average quantity of 0,633g per cigarette (Deutscher Bundestag, 2006) in addition, an ad-valorem tax of 25% of retail price is applied. However, marijuana as a product is probably more similar to chopped tobacco sold for rolling cigarettes. Chopped tobacco is taxed at 38 CHF/kg and an additional 25% of retail value. In comparison to tobacco tax rates I assume in this scenario double the ad-valorem rate of 25% (50%) and a weight specific rate that is about 126 times the amount of chopped tobacco and 26 times the amount when compared to cigarettes (for marijuana). For resin the factors are 208 (compared to chopped tobacco) and 44 (compared to cigarettes.

However, even with these significantly higher tax rates, the tax revenue for cannabis products generated by this particular taxation scheme is still dwarfed by the 2.2b CHF generated by the

[88] This is a practical maximum. Theoretically the tax rate could be increased to even higher rates, however, this does not seem a plausible alternative given the public-health aims of regulatory changes and given market sensitivity to price differentials between licit and illicit cannabis (see Figure 21).

tobacco tax. It is however important to keep in mind, that the consumption quantities between the two substances also differs widely. Based on the latest data from cigarette sales (Federal Cus-toms Administration FCA, 2020b) about 9.3b cigarettes were sold in Switzerland in 2020. This corresponds to about 5.9m kg or 5.900t of tobacco[89]. In comparison to the estimated consumption amount of about 56t of cannabis for this scenario this is more than 105 times the consumption amount for cigarettes.

5.4 Free-Market scenario: Commercial legalisation with for-profit market and little cannabis-specific regulations

The Free-Market scenario was created using three key pillars:

- a commercial organisational form for the production and trade of cannabis,
- very little product specific regulation and a focus on commercial freedom
- low and product unspecific taxation

This scenario is a stylized case of a commercially driven regulation scenario focused on free market processes very little regulation and no specific form of taxation. It represents a mix of the last two scenarios in the band with outlined in Figure 19 between the standard commercial model and a prohibition repeal-only approach. The reason why this scenario was selected for the analysis is because it can be used as an example for the economic effects associated with a fully commercialised cannabis market mostly unaffected by substance-specific regulation. It allows the simulation of a very competitive market including connected effects such as increases in quantity and quality of production capacity, product pricing near cost prices, increased consumption quantities, etc. In

[89] This is only the tobacco quantity for cigarettes, there are other tobacco products which also contribute to the total sum of tobacco tax but are not explicitly addressed here to due to comparably low quantities in the market.

a way, it serves as a benchmark as to what the market could achieve, if it were to operate largely unrestraint from product specific regulation and taxation. It thus serves, from an economic perspective, as a lower-bound estimate. Since no product-specific taxation is applied (with the exception of VAT) the ability to internalise externalities, as was shown in the High-Regulation scenario, does not apply to the same extent.

5.4.1 Regulatory variables and assumptions

In comparison to the status quo, this regulatory scenario changes the following regulatory variables about the cannabis market in Switzerland:

- **Retail Market**: I assume in the medium term a fully crowded out illicit market and a demand fully met by legal means[90]. The market is comprised of private sector entities selling cannabis products to adult customers through normal commercial channels such as supermarkets, kiosks, or specialised shops.
- Retail regulation:
- The age limit for legally purchasing and possessing cannabis is 18 years
- Production and trade:
- Professional production capacity for both marijuana and resin
- Requirements with respect to labelling and analytical transparency
- Legal employment for production, distribution, and management personnel

[90] Based on experiences in other jurisdictions, this assumption is not unreasonable (Knudson & Miller, 2020).

- **Cannabis accessibility**: It is assumed that there is widespread availability of cannabis to satiate market demand. Accessibility is not assumed to be a limiting factor for demand.
- **Marketing**: Marketing of cannabis products is generally allowed with limitations to marketing activities specifically addressed to minors.
- **Domestic production**: Domestic industrial production for commercial purposes is legal. Homegrowing is also permitted for both personal consumption and with commercial intent. There are no limitations with respect to the location and visibility of private production operations.
- **Import and export**: The import and export of cannabis remains prohibited. Effects related to regulatory changes abroad are not addressed in this project.
- **Policing**: There is no change in policing intensity for illegal market activity such as import and export.
- **Taxation**: There is no product specific taxation and cannabis products are taxed at average VAT rates for agricultural consumer goods.

5.4.2 Results

Figure 30, Figure 31 and Table 33 show the results of the scenario from three different perspectives. Figure 30 shows the aggregate results in gross output for the market segment on the direct and indirect level, Figure 31 breaks down the gross output into the individual components and Table 33 shows the overall results for the entire cannabis system. This scenario combines various effects seen in the previous scenarios which leads to an overall significant decrease in the economic effects. Total gross output for the market segments decreases by 84% from 843m CHF to 133m CHF. The decreases in every single effect (-58% IIE, -89% Income effect, -87% direct effect) are caused by a series of effects that can partially be seen in the other scenarios. There is the repatriation of previously imported market segments (Figure 31), there is the significant decrease in profit margins for the domestic production and trade (Figure 31), there is a highly efficient agricultural production, wholesale and retail trade system including average profit margin for similar products (Figure 31) and most importantly this scenario is calculated with average retail prices just above cost prices (0.86 CHF/g marijuana, 0.36 CHF/g/ resin). Even though the decrease in retail prices drives up demand (32% marijuana, 34% resin, see chapter 5.1), total gross output decreases, because the increases in demand does not fully substitute the combined strength of the economic effects of a legalised commercial market.

While retail prices are lower compared to previous market prices, they reflect realistic assumptions about production and trade costs by Swiss standards, average profit margins unaffected by additional product-specific regulation and taxation. A competitive market-based regulation would likely move towards a similar situation in the medium term. [91] Saffer & Chaloupka (1999) for example calculated the effects of cannabis decriminalization empirically with data from about 50’000 participants of the National Household Survey of Drug Abuse as well as from the Drug Enforcement Agency. They approximate that an end to drug prohibition would cut retail drug prices by about 60% based on their data sample (p. 14).

The following tables and graphs show the simulated results in comparison to the status quo.

[91] Similar developments can be seen in commercial regulation scenarios abroad (Caulkins et al., 2018; Knudson & Miller, 2020; Smart et al., 2017; Swanson & Gamio, 2015)and even in the regulated CBD market in Switzerland (Anonymous informant #2, personal communication, 15 February 2021; S. Senn & L. Cereghetti, personal communication, 4 June 2021; Sven Schendekehl, personal communication, 4 June 2021).

Figure 29: Estimated change in total gross output for the cannabis market status quo vs. Free-Market scenario (in m CHF)

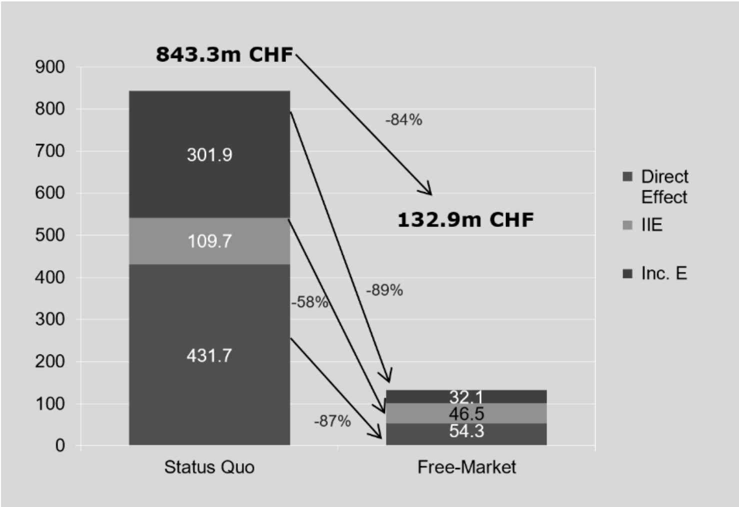


Figure 31 breaks down the total expenditure into the individual components and shows just how strongly the change in regulation affects the market structure of cannabis in Switzerland. The most obvious effect, when comparing it to Figure 29 is the lack of product specific taxation. The assumption to tax cannabis product at average VAT rates of agricultural consumer goods has a twofold effect. On the one hand retail prices will be much lower (as there is no product specific tax applied), which increases consumption and on the other hand there is a large decrease in tax revenues (when compared to the High-Regulation scenario for example). The actual product tax revenue generated by the VAT in this scenario amounts to only 4.2m CHF or just short of 1% of the product tax revenue generated in the High-Regulation scenario (454m CHF). Since VAT is a value-based tax, it would fluctuate with changes in retail prices (e.g. during market adjustment in the short term).

Figure 30: Cannabis expenditure of the market segment; status quo vs. Free-Market scenario (in m CHF)

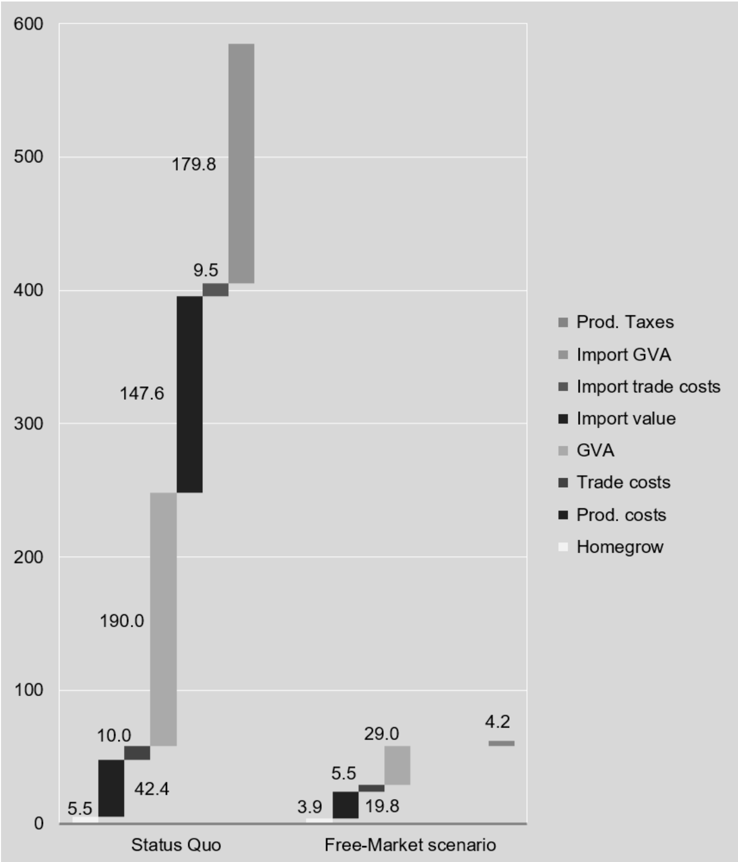


Table 33 presents the overall results for the economic impact estimation for scenario 3 and combines the effect of the market segment with the non-market segments. In aggregate, gross output for the entire cannabis system in the Free-Market scenario amounts to 192m CHF, down from 1000m in the status quo. The effects of the increase in demand on the market are limited given the assumed low retail prices and efficient market provision of final goods. As per our assumption, effects of healthcare provision increase linearly with consumption and thus increase to 59m CHF (dir. and indir.) compared to 44m CHF in the status quo. The other non-market segments dwindle in economic relevance, as the vast majority of activities related to cannabis production, possession and trade are legal in this scenario. Just how much more "efficient" the cannabis system is operating in this scenario can be seen when comparing the employment effect.

Table 33: Results economic effects cannabis system Free-Market scenario

	Gross Output in m CHF	Gross value added in m CHF	Employment in FTE[1]
Direct effects	**84**	**50**	**348**
Court enforcement	0.07	0.04	0.15
Jurisprudence	0.06	0.05	0.28
Police	0.21	0.14	1
Healthcare	29.9	20.4	165
Market	54.3	29.0	182
Indirect effects	**94.2**	**44.4**	**370**
Income effect	47.5	25.4	164
Court enforcement	*0.02*	*0.01*	*0.06*
Jurisprudence	*0.05*	*0.02*	*0.16*
Police	*0.12*	*0.06*	*0*
Healthcare	*15.3*	*8.1*	*53*
Market	*32.1*	*17.2*	*111*
Intermediate input effect	46.6	19.0	206
Court enforcement	*0.02*	*0.01*	*0.06*
Jurisprudence	*0.01*	*0.01*	*0.05*
Police	*0.10*	*0.05*	*0*
Healthcare	*13.5*	*5.7*	*32*
Market	*46.5*	*18.9*	*205*
Total effects dir. + indir.	**192**	**100**	**750**
Court enforcement	0.09	0.06	0.3
Jurisprudence	0.12	0.09	0.5
Police	0.43	0.25	2
Healthcare	58.7	34.2	250
Market	133	65.1	498
Taxes, penalties and fines	**11.5**		
Court enforcement	0.00	(0.04%)	
Jurisprudence	0.01	(0.07%)	
Police	0.03	(0.22%)	
Healthcare	2.7	(23.01%)	
Market other.	4.6	(40.25%)	
Market prod.	4.2	(36.22%)	
Penalties and fines	0.02	(0.19%)	

1) Full time equivalents

While the status quo triggers a direct employment effect of 2.320 for the market segment, this number drops to 308 (about 13% of the initial effect) in the legalised and largely unregulated commercial market even when facing an increased demand.

5.4.3 SUMMARY

Chapters 5.2, 5.3, and 5.4 present and interpret the estimation results for the effects of stylized regulatory scenarios on the cannabis system overall as well as for the individual segments. Table 34-38 show the summarised results for both the status quo and the regulatory scenarios for gross output, gross value added, employment effect as well as tax revenue, penalties and fines.

Table 34: Total gross output (dir.+indir.) status quo and scenarios

	Status Quo in m CHF	CSC in m CHF	High-Regulation in m CHF	Free-Market in m CHF
Direct effects	**512**	**313**	**116**	**84.5**
Court enforcement	13.9	5.0	0.06	0.07
Jurisprudence	9.4	2.1	0.1	0.06
Police	34.3	6.7	0.2	0.21
Healthcare	22.5	24.0	22.5	29.9
Market	431.7	275	93	54.3
Indirect effects	**488**	**326**	**149**	**94.2**
Income effect	345	182	67.2	47.5
Court enforcement	*4*	*1.8*	*0.01*	*0.02*
Jurisprudence	*7*	*1.5*	*0.04*	*0.05*
Police	*20*	*4.0*	*0.11*	*0.12*
Healthcare	*12*	*12.3*	*11.5*	*15.3*
Market	*302*	*163*	*55.5*	*32.1*
Intermediate input effect	143	143	81.8	46.6
Court enforcement	*4*	*1.8*	*0.01*	*0.02*
Jurisprudence	*2*	*0.47*	*0.01*	*0.01*
Police	*17*	*3.3*	*0.1*	*0.10*
Healthcare	*10*	*10.9*	*10.2*	*13.5*
Market	*110*	*138*	*81.7*	*46.5*
Total effects dir. + indir.	**1,000**	**650**	**275**	**192**
Court enforcement	22.7	9.4	0.07	0.09
Jurisprudence	18.3	4.1	0.11	0.12
Police	71.1	14.0	0.39	0.43
Healthcare	44.2	47.2	44.2	58.7
Market	843.3	576	231	133
Taxes, penalties and fines	**25.4**	**166**	**464**	**11.6**
Court enforcement	1.07	0.44	0.00	0.00
Jurisprudence	1.21	0.27	0.01	0.01
Police	4.26	0.84	0.02	0.03
Healthcare	2.01	2.1	2.0	2.7
Market other.	12.89	13.8	8.0	4.6
Market prod.	0.00	148	454	4.2
Penalties and fines	3.96	0.65	0.02	0.03

Total gross output (dir.+indir.), which corresponds to revenue[92] for most industries, is estimated between 1b CHF in the status quo and 192m CHF in the Free-Market scenario. The changes in gross output between the different scenarios are caused by multiple effects. One effect is the change in the quantity of economic processes in the cannabis system. As the effects for court enforcement, jurisprudence and police show, the total effects caused by these segments decreases between the status quo and the scenarios, because the economic activity previously triggered by the illegality of cannabis ceases to be necessary, when different aspects of cannabis become legal.

The second effect is that the value of the economic activity that remains changes. Whereas in the status quo, cannabis products are traded between 10-13 CHF/g, this value changes to less than 1 CHF/g in the Free-Market scenario. While there is also an associated decrease in the production costs of cannabis, this effect is not sufficient to counteract the decrease of trade margins, which in effect causes the direct (and indirect effects) of the market segment to drop (843m CHF in the status quo, 576m CHF in the CSC scenario, 231m CHF in the High-Regulation scenario and 133m CHF in the Free-Market scenario).

A third effect, which feeds into the changes in gross output is the repatriation of economic activity from abroad. Whereas in the status quo and in the CSC scenario a share of consumption demand is provided through illegal imports from abroad, these quantities are domestically produced to different degrees in the regulation scenarios at prices, that are well below the illicit import value. The economic effects from the domestic trade of the imported quantity in the status quo largely consists of wage equivalent incomes (as part of the trade margin). Since in the regulatory scenarios the GVA generated by the domestic production is mostly

[92] Except for margin based industries such as retail and wholesale trade where it is defined as revenue less costs of goods (Bureau of Economic Analysis, 2018).

taxed, the revenue that previously triggered indirect incomes, now goes to the state in the form of product taxes.

Gross value added, which represents gross output without intermediate inputs is a more accurate description of the economic effects as it includes primarily labour and capital used for producing the gross output. Whereas the majority of changes in value added follow the same pattern as the gross output, this is different for the market segment. As Table 35 shows the income effect from the market segment drops from 162m CHF in the status quo to 87m CHF in the CSC scenario, 30m CHF in the High-Regulation scenario and just 17m CHF in the Free-Market scenario.

Table 35: Total gross value added (dir.+indir.) status quo and scenarios

	Status Quo in m CHF	CSC in m CHF	High-Regulation in m CHF	Free-Market in m CHF
Direct effects	**428**	**223**	**65**	**49.7**
Court enforcement	10.7	4.4	0.03	0.04
Jurisprudence	8.1	1.8	0.05	0.05
Police	24.0	4.7	0.13	0.14
Healthcare	15.4	16.4	15.4	20.4
Market	370	196	49.0	29.0
Indirect effects	**245**	**162**	**69**	**44.4**
Income effect	184	98	35.9	25.4
Court enforcement	*2.4*	*0.99*	*0.01*	*0.01*
Jurisprudence	*3.6*	*0.80*	*0.02*	*0.02*
Police	*10.7*	*2.1*	*0.06*	*0.06*
Healthcare	*6.1*	*6.5*	*6.1*	*8.1*
Market	*162*	*87.1*	*29.7*	*17.2*
Intermediate input effect	60.5	64.3	33.2	19.0
Court enforcement	*2.1*	*0.87*	*0.01*	*0.01*
Jurisprudence	*1.0*	*0.22*	*0.01*	*0.01*
Police	*7.7*	*1.5*	*0.04*	*0.05*
Healthcare	*4.3*	*4.6*	*4.3*	*5.7*
Market	*45.4*	*61.7*	*33.1*	*18.9*
Total effects dir. + indir.	**673**	**390**	**138**	**100**
Court enforcement	15.2	6.3	0.05	0.06
Jurisprudence	12.7	2.8	0.08	0.09
Police	42.4	8.3	0.23	0.25
Healthcare	25.8	27.5	25.8	34.2
Market	576.7	344.6	112	65.1
Taxes, penalties and fines	**25.4**	**166**	**464**	**11.6**
Court enforcement	1.07	0.44	0.00	0.00
Jurisprudence	1.21	0.27	0.01	0.01
Police	4.26	0.84	0.02	0.03
Healthcare	2.0	2.1	2.0	2.7
Market other.	12.9	13.8	8.0	4.6
Market prod.	0	148	454	4.2
Penalties and fines	3.96	0.65	0.02	0.03

This effect is caused by the changes to the structure of the gross value added. Whereas in the status quo, the largest share of value added generated in the market segment consists of wage equivalent incomes or profits by producers, wholesale and retail traders, different tax schemes are applied in the regulatory scenarios that divert a share of these margins into product taxes which can then be used for the provision of public services or public-health initiatives. The increase of the intermediate effect for the market segment between the status quo is related to the designated share of revenue that the CSCs can use for member-related activities (counselling, research, information, etc.). The comparison of the direct gross value added of the entire cannabis system plus the product taxes with Swiss GDP data yields .062% for the status quo, .053% for the CSC scenario, .075% for the High-Regulation scenario and .008% for the Free-Market scenario.

The increase in GVA and share of GDP for scenario 2 is caused by the high degree of taxation that is applied in this scenario and needs to be interpreted as an upper bound. Similar approaches in estimating the GDP effect of illegal drugs for Germany were conducted by Taschowsky, (2015) who estimates GVA for 5 types[93] of illegal drugs of 1.2b EUR or 0.05% of GDP for 2010.

[93] Cocaine, Heroin, Amphetamines, Cannabis, Ecstasy.

Table 36: Total employment effect (dir.+indir.) status quo and scenarios

	Status Quo in FTE[1]	CSC in FTE[1]	High-Regulation in FTE[1]	Free-Market in FTE[1]
Direct effects	**2,686**	**1,417**	**433**	**348**
Court enforcement	37.0	15.2	0.12	0.15
Jurisprudence	41.0	9.1	0.26	0.28
Police	164	32.2	0.9	1.0
Healthcare	124	132	124	165
Market	2,320	1,228	308	182
Indirect effects	**1,759**	**1,244**	**596**	**370**
Income effect	1,193	631	233	164
Court enforcement	*15.3*	*6.3*	*0.05*	*0.06*
Jurisprudence	*23.5*	*5.2*	*0.15*	*0.16*
Police	*69.5*	*13.7*	*0.38*	*0.42*
Healthcare	*39.7*	*42.3*	*39.7*	*52.6*
Market	*1,045*	*563*	*192*	*111*
Intermediate input effect	566	613	363	206
Court enforcement	*14.0*	*5.8*	*0.05*	*0.06*
Jurisprudence	*7.0*	*1.6*	*0.04*	*0.05*
Police	*54.0*	*10.6*	*0.30*	*0.32*
Healthcare	*24.0*	*25.6*	*24.0*	*31.9*
Market	*467*	*596*	*363*	*205*
Total effects dir. + indir.	**4,445**	**2,687**	**1,053**	**750**
Court enforcement	66.0	27.2	0.21	0.27
Jurisprudence	71.0	15.7	0.44	0.48
Police	288	56.6	1.6	1.7
Healthcare	188	201	188	250
Market	3,832	2,387	863	498

1) Full time equivalents

Table 36 shows the estimated employment effects associated with the economic effects triggered by the cannabis system. Whereas the status quo causes an employment effect of around 4,450 FTEs, this effect is reduced to 750 FTEs in the Free-Market scenario. The development of employment effects is closely linked to the development of value-added. The reason for the continuous decrease in employment effects is thus threefold. On the one hand, a large share of revenue is converted to taxes in the CSC and High-Regulation scenario and thus does not trigger indirect effects through intermediate inputs or consumption, on the other hand, the cannabis sector is significantly increasing in efficiency from the status quo, to a very efficient production and trade in the Free-Market scenario. With the corresponding decrease in prices, the total revenue derived from producing and trading cannabis drops off. The third reason is again the fact, that some activities in the cannabis segments will not occur anymore, if regulation is changed, whereas others (such as healthcare) might increase, through potential increases in use.

Table 37: Taxes penalties and fines status quo and scenarios

	Status Quo in m CHF	CSC in m CHF	High-Regulation in m CHF	Free-Market in m CHF
Taxes, penalties and fines	**25.4**	**165.7**	**463.92**	**11.55**
Court enforcement	1.07	0.44	0.00	0.00
Jurisprudence	1.21	0.27	0.01	0.01
Police	4.26	0.84	0.02	0.03
Healthcare	2.01	2.1	2.0	2.7
Market other	12.89	13.8	8.0	4.6
Market prod.	0.00	147.5	453.9	4.2
Penalties and fines	3.96	0.65	0.02	0.03

Finally, Table 37 summarises the estimated effects for taxes, penalties and fines. Whereas the status quo does not have a direct form of taxation for the market segment, the regulatory scenarios each have a specific taxation scheme applied. The CSC scenario operates with a price floor and a sales tax, the High-Regulation scenario applies an arguably very high combined tax with a weight-based component and an ad-valorem component. The Free-Market scenario does not include a product specific form of taxation but, contrary to the status quo, applies VAT on cannabis consumption expenditure. As the table shows, the product tax-revenue ranges between 0 CHF, in the status quo, to about 454m CHF in the High-Regulation scenario. The CSC scenario with about 148m CHF and the Free-Market scenario with 4.2m CHF are in between those two estimates. For the interpretation it is important to keep in mind, that the regulatory scenarios and the taxation schemes applied are of a stylized nature and do not necessarily correspond to sensible regulatory approaches. The High-Regulation scenario, as an example, assumes an upper boundary taxation that assumes a post-tax retail price equal to the current illicit market. To achieve this, the tax rate for marijuana is set at 26 times the per gram tax rate of tobacco. It thus constitutes more of a theoretical upper boundary, whereas the Free-Market scenario represents a lower boundary with a legal, efficient market and no product specific taxation. The CSC scenario on the other hand estimates a middle-ground approach with retail prices regulated lower than the current illicit market and a sales tax of 60%.

The product tax perspective needs to be combined with other taxes, e.g. net-product-taxes (VAT, tobacco, fuel, etc.) and income taxes paid on the generated incomes and consumption expenditure by households and industries to obtain the full tax impact of the cannabis system. However, as Table 37 shows, the indirect taxes make up a relatively low share of total tax revenue for the scenarios where product taxes are applied.

CHAPTER 6: UNCERTAINTY AND SENSITIVITY ANALYSIS

In Chapter 3 I explained the rationale for using point estimates for the purpose of this study, rather than a bandwidth approach. However, this approach does not mean, that the estimation conducted in this study is not affected by the lack of or the quality of the data that it is based on. On the contrary, Chapter 3 and Chapter 5 contain a discussion on the validity of the data sources used as well as on the academic literature from Switzerland and other jurisdictions discussing the empirical and theoretical ranges of the various estimation variables.

For the interpretation of the results of this estimation it is thus important to understand how the uncertainty of the used data and variables affect the overall estimation outcomes. To this end, this chapter will go into more detail about the sensitivity effects of the most important variables used. The first part of the chapter deals with the estimation of the status quo (Chapter 3) and the second chapter will discuss variables used in the estimation of the regulatory scenarios (Chapter 5).

For the purpose of analysing the sensitivity of the model which I constructed in Chapter 3, four variables and the impact of their variability on the overall results will be investigated further in this chapter. The overall consumption quantity, the average retail price, the import rate for marijuana and resin products respectively and the price elasticity of demand. There are two reasons, why I selected these variables for the sensitivity analysis. On the one side, these variables have a large degree of inherent variability based on the sources they were estimated from. On the other hand, the variability of these variables has a significant impact on the estimated results and thus exemplifies the uncertainty of the results.

6.1 Consumption quantity

6.1.1 Estimated value

Table 4 presented the total estimated consumption quantities for both marijuana and resin in Switzerland. Excluding police seizures, I estimated the consumption volume at 39.3t for marijuana and 16.7t for resin.

6.1.2 Sources of uncertainty

Briefly summarised, the estimated consumption quantities are based on self-reported consumption behaviour and quantities from population representative survey data for Switzerland. Three potential sources of uncertainty were accounted for during the estimation process. The first being the adjustment of the total number of consumers in order to include people not (adequately) captured in population surveys. The second source of adjustment was correcting the survey-based consumption variables using a literature-based adjustment factor for underreporting (see Chapter 3 for more details). Zobel et al. (2020, p. 70) discuss the potential range of the sources of uncertainty, that are meant to be addressed by these two adjustment processes and conclude, that the potential range of the pre-adjustment value lies with 95% confidence within an adjustment factor interval of 0.94 and 1.43. Since the methodology used for Chapter 3 builds on the work and data of Zobel et al. (2020), it makes sense to use this range as a bandwidth for the sensitivity analysis.

6.1.3 Sensitivity of the model

Table 4 presented the total estimated consumption quantities for both marijuana and resin in Switzerland. Including police seizures, I estimated the consumption volume at 41.7t for marijuana and 17.3t for resin.

If I apply the aforementioned adjustment range to the pre-adjustment quantities, the resulting bandwidth is 22.9t – 33.7t for marijuana and 11.9t – 14.4t for resin. These values represent pre-WBE-adjustment estimates.

The final step of the adjustment consisted of further adjusting towards a "true" value by additionally increasing the resulting estimate toward the median value between the adjusted, survey-based estimate and a WBE-based consumption estimate as an upper-bound boundary. Applying the same adjustment process to the pre-WBE-adjustment bandwidth (+22.9%) yields the final bandwidth of 28.2t – 41.4t for marijuana and 11.9t – 17.6t for resin. The sensitivity analysis for the consumption quantity for marijuana and resin thus shows, that the results estimated in this study are at the upper end of the WBE-adjusted survey-based bandwidth, which is a direct result of the adjustment factor used for my estimation (1.35). Since the study is based on a point estimate approach, I had to decide on a single factor, rather than a bandwidth. The reason for the selection of this adjustment factor at the upper end of the literature-based adjustment spectrum is twofold. On the one hand, the WBE of cannabis consumption quantity is significantly higher, than the survey-based estimate. Even allowing for methodological issues and uncertainty in the measurements and regional application, this indicates, that the "true" consumption quantity is likely higher, than even the adjusted survey-based estimate and thus in return potentially justifying a higher adjustment factor. The second reason is, that similar research with other, legal substances show, that the actual underreporting quantity in survey based estimates can, depending on the context, population and methodology, be even higher in the range of 38% (wine), 49% (beer) 65% (spirits) (Cook, 2007;

Stockwell et al., 2014) suggesting significantly higher adjustment factors between that could even exceed 2.

6.2 Retail prices

6.2.1 Estimated value

Chapter 3.1.2 describes the available data on retail prices in Switzerland and Europe. Based on the available data, the estimations in this study were run based on an estimated average retail price of 10 CHF/g for marijuana and 13 CHF/g for resin.

6.2.2 Sources of uncertainty

As discussed in Chapter 3.1.2, the available quantitative market data for cannabis retail markets is very limited in Switzerland. With the exception information from cantonal police forces based on drug seizures, unrepresentative information from voluntary mobile drug-checking services offered by drug counselling institutions and survey-based information from the European Web Survey on Drugs, there is no reliable source of transactional data including variables such as quantity, price, potency, etc. Qualitative information on cannabis markets indicates that there are different market forms for cannabis products: private, semi-public and public markets (Pignolo, 2017, 2020; Sandberg, 2012 as cited in Zobel et al., 2020). Each market has different forms of actors, relationships, modes of transaction, trust and distrust and pricing models. The respective size of each of these market segments, their pricing models and the customer base and their consumption behaviour, however, is largely unknown. Because there is little information on cannabis market segments and the aforementioned variables directly influence retail prices there is uncertainty as to the average retail price in Switzerland. Zobel et al. (2020), as well as the interviews I conducted with police officials on the cantonal level, indicate that retail prices for marijuana can range from 8 CHF/g to 20 or even 30-40/g CHF in extreme cases always depending on the market segment, the context of the transaction as well as the actual product and its potency. Similar ranges are mentioned for resin products (10-20 CHF/g).

6.2.3 SENSITIVITY OF THE MODEL

Since the average retail prices are used for the valuation of the consumption quantities and thus constitute the last step during the valuation of the market segment, they influence the final results significantly. Even small changes have a large leverage on the calculated turnover. Changing the variable for marijuana for example yields a bandwidth of 73m CHF (328m – 365m – 401m CHF) in total market revenue when running the calculations with average retail prices of 9/10/11 CHF/g respectively. The situation is similar for resin where the same +- 1 CHF/g change yields a total market revenue of 201m – 217m – 234m for 12/13/14 CHF/g or a bandwidth of 33m CHF. Combining both products shows that a 1 CHF change in average retail prices would change the market revenue by about 53m CHF. Additionally, the economic effects triggered by this market revenue (e.g., tax revenue, employment effects, etc.) would be impacted linearly as well.

6.3 IMPORT SHARE

6.3.1 ESTIMATED VALUE

A significant share of the market for marijuana and resin is provided not by domestic production, but by imports from abroad. Chapter 3.1.2 describes the lack of data on the issue and the qualitative inputs from the cantonal police forces. I used a conservative estimate of 33% as the import share for marijuana in this estimation.

6.3.2 Sources of uncertainty

Unfortunately, the data available on the import share of cannabis products sold in Switzerland is lacklustre. The only credible source I was able to source during my research were expert opinions of police representatives who in return base their judgement on seizures, investigations and police interviews with suspects as well as some interviews with cannabis industry pundits (e.g. commercial CBD producers, grow-shop owners). The interviews revealed that the import share for marijuana lies somewhere between 30-70% with a focus on 30-50%. For the calculation of the economic effects associated with the cannabis market I used an import share of 33% which corresponds to the lower end of the bandwidth. This was done primarily, because the interviews indicated, that the domestic production capacity and professionalism has significantly increased in the last 10-15 years. For resin products, there was a consensus that almost all resin products in Switzerland are imported from abroad except for very small quantities. For this reason, I used an import share of 100% as a simplified assumption

6.3.3 Sensitivity of the model

Contrary to the retail prices and the consumption quantity, the import share of marijuana does not directly influence the revenue of the market. It does however significantly impact the distribution of economic effects. Whereas a lower import share increases the domestic effects, as the economic activity is now substituted domestically, a higher import rate leads to the opposite. In order to quantify this effect, I have simulated an increase in the import share for marijuana in the model from 33% to 50%. This causes several effects. First and foremost, the import value of marijuana increases by 34m CHF from 64m to 98m CHF at the expense of a decrease in the domestic production value from 297m to 264m. In consequence, the economic effects triggered by this decrease in domestic production value (e.g., tax revenue, employment effects, etc.) are reduced as well as a larger share of economic activity now occurs outside of Switzerland.

6.4 PRICE ELASTICITY OF DEMAND

6.4.1 ESTIMATED VALUE

The price elasticity of demand for cannabis describes the degree to which changes in cannabis prices affect the consumption of cannabis. Chapter 5.1.5 5.1discusses the literature and the considerations which were used to determine the total elasticity of demand of -0.35 used for the calculations of the three regulatory scenarios.

6.4.2 SOURCES OF UNCERTAINTY

For understanding the difficulty of determining an estimate for the total elasticity of demand (TPE) it is important to understand, that total elasticity of demand consists of two different elements: the *participation elasticity* (the likelihood that someone decides to start or stop using cannabis) and the *conditional elasticity* (the quantity a user decides to use at any given price) (Ouellet et al., 2017, p. 14). There are a number of factors, that influence the validity of the studies on the subject:

- Whereas the participation elasticity can be estimated by using price data in combination with past-use data (e.g. consumption yesterday, past-month or past-year), conditional elasticity would require additional information on consumption quantities which is/was often times not available in the data used for studies which tried to estimate price elasticity of demand (Pacula et al., 2009; J. Williams, 2004).
- A second issue with the literature on the subject relates to the fact, that a lot of the studies are only representative for a

certain sub-set of the population (e.g. college students, school-children, young-adults, etc.).

- In addition, in the absence of transactional data for cannabis products, a significant number of the studies dealing with the price elasticity of demand rely on proxy information on price developments from sources such as the Drug Enforcement Agency (Pacula et al., 2009) or state commissioners of police (Cameron & Williams, 2001).
- Using transactional data either obtained by crowdsourcing (A. J. Davis et al., 2016) or by interviews (Ben Lakhdar et al., 2016) circumvents some of the issues related to using nationally representative population data, however, it comes at the cost of generalizability of the results (Kraemer et al., 2017).
- Last but not least, total price elasticity is a concept that depends on the economic context of the market. Typically cited influence factors are availability and price of substitutes, the price in relation to consumer income, complementarity between goods as well as the timeframe involved in the comparison (University of Minnesota Libraries Publishing, 2016). It is thus important to keep in mind, that results from any given country or region cannot easily be transferred to other jurisdictions.

6.4.3 Sensitivity of the model

Ouellet et al. (2017, p. 20) summarise the literature on the topic and conclude that total price elasticity can range between -0.67 to -0.79 (continental U.S.) to -1.01 - -1.51 (US college samples) to -1.7 - -2.1 (France, heavy Cannabis users).

Applying a significantly higher price elasticity of demand than the -0.35 used in this study, changes the effects of the regulatory scenarios. In order to examine the sensitivity of the model I calculated the scenarios for both a TPE of -1 and -2 respectively to capture the range of the literature. Just how much of a difference this change can make is best seen in the free market scenario. As a brief reminder, the average retail prices drop from 10/13 CHF/g in the status quo to 0.86/0.36 CHF/g in the free-market scenario due to price pressure through competition and an absence of product specific taxation. This corresponds to a very steep price decrease of 91% for marijuana and 97% for resin which constitutes a very large lever for the TPE.

When applying both a price elasticity of demand of -1 and -2 respectively, there are several two striking changes. The total demand would change from 49t/22t (marijuana/resin) to 70t/33t (TPE of -1) and 103t/49t (TPE of -2) essentially doubling the estimated consumption quantity. In monetary terms this would mean, that the market revenue (incl. VAT) would jump from 58m to 85m CHF (TPE of -1) and 125m CHF (TPE of -2). The economic effects triggered by these changes in the market revenue (e.g., tax revenue, employment effects, etc.) would be impacted linearly as well.

The simulation of a TPE of -0.35, -1 and -2 shows, how sensitive the demand side in the model reacts to changes in the price of cannabis products. Obviously, this effect is noticeably stronger, if the assumed price changes are large (as it is the case in the free-market scenario). The changes in market revenue (485m to 532m and 605m CHF) and consumption quantity (47t/10t to 53t/11t and 62t/12t CHF) are correspondingly smaller, as are the price changes.

6.5 Summary

The sensitivity analysis for the variables consumption quantity, average retail prices, import share and price elasticity of demand were conducted individually for each variable. Each simulation is thus based on the ceteris paribus assumption, so all other variables are held constant to distinguish the sensitivity for each individual variable. In reality, it is obviously possible and likely, that the uncertainty of each individual variable overlaps and interacts with other variables.

The analysis has shown that the inherent uncertainty that exists in the data, which was used for this analysis, can have significant effects on the range of the results of the estimation. For the interpretation of the results, it is thus paramount to consider the limitations of the underlying data as well as the range of the results. The analysis has further revealed that a more detailed understanding of the cannabis system is depended on robust and reliable data. Further research should thus be conducted to improve the understanding of the cannabis system in Switzerland. This is especially relevant, if a potential change in regulation should be considered in the future and a connected goal is to set up an evaluation concept for the investigation of potential causal relationships.

Chapter 7: Concluding Remarks

To conclude the thesis this chapter is split into two subchapters. The first part gives a brief overview of several topics and research questions related to the theme of this report. These topics further investigate specific aspects that were touched briefly but not enlarged upon or present additional considerations that are in my view relevant to the topic but could not yet be included.

The second part of the chapter constitutes the conclusion of the report. It revisits the original research objectives and summarises the main findings in light of the identified research gap. Additionally, Chapter 7.2 contains recommendations for future research and addresses implications for policy makers.

7.1 Related topics

In addition to the different variables included in the estimated scenarios in Chapter 5, there are other topics not specifically addressed. These topics are relevant for the discussion of economic effects but were beyond the scope of this study. One of these topics is the timing of the different effects. The scenarios created in this project are all based on the assumption of a medium-term perspective because this project is focused on the outcomes of economic adjustment processes rather than on the adjustment process itself. I have thus taken a perspective not focused on the immediate effect once regulation is applied, but rather on the situation a few years after regulation has been applied and when I assume that the different segments of the cannabis system have had time to adjust. However, in the real world, we would probably see several effects acting over various time horizons when looking at regulatory change from a temporal perspective. Some of these effects are likely more relevant in the short term and of a temporary nature, e.g. "experimental" users, industry adjustments to the new regulatory regime, increases in capital expenditure for the change in production capacities, and changes in the focus of policing activity. Other effects might be more relevant in the medium-term and of a more permanent nature, e.g. changes in product diversification, potential changes in the perceived risk of cannabis, and potential changes to consumption patterns.Additional effects could be relevant in the very long-term, e.g. changes to the age-of-onset (Cervený et al., 2015), demographic effects, and cohort effects (Vogel et al., 2019).

Another issue which was not explicitly addressed are the effects of alternative regulation on both the range of cannabis products available to the market as well as on their potency. There is empirical evidence from the U.S. that the portfolio of products available on the legal market expanded rapidly and widely (Caulkins et al., 2015b, 2018; Smart & Pacula, 2019). Similar experiences were made in the CBD market in recent years. Marijuana and resin are now only two products among many including oils (like bhutane hash oil), edibles, highly potent extracts (wax, shatter, butter, see Figure 21, page 181). Not only have products diversified, but consumption forms associated with these products also have changed. Whereas smoking cannabis or resin used to be the primary form of consumption, now other forms of inhalation such as "dabbing" (consuming extracts with specialised rigs similar to water-pipes), vaping (using vape pens and cartridges) and eating are become increasingly popular. While one reason for the diversification of the product portfolio are regulatory incentives (e.g. in the form of varying taxation across different products to disincentivise the consumption of tobacco), others are common market processes within a competitive market environment (product diversification, marketing, innovation) and another is a change in consumer preferences.

For the topic of this project these distinctions are relevant on different levels. On the one hand a diversification of cannabis products would likely have an impact on the estimation of the market. Different products have different production costs as they are made by processing cannabis plants in various ways (see Figure 21, page 181). They have different retail costs and require different paraphernalia. On the other hand changes in the potency of products and changes in the consumption form could impact the healthcare system by increasing the likelihood or severity of adverse health effects (Budney & Borodovsky, 2017). Some products available on the market have a THC content between 70-90% which is multiple times the average potency of marijuana or resin (see Figure 8). However, it is not only the potency of the products that could influence their potential impact on the healthcare system. Alternative and fairly new consumption forms can carry their own risks, as was shown by the recent outbreak of a pulmonary illness related to vitamin E acetate ("vaping disease") in illicit market cannabis products for vaping that left 68 people dead and 2.800 people hospitalised in the U.S. (Centers for disease control and prevention, 2020; Layden et al., 2019). Other issues connected to product diversification are related to products specifically catered to the interest of vulnerable population groups (e.g. adolescents) and associated incentives to pick up or intensify consumption. A case in point was the surge of alcopops around the turn of the millennium and the increase in associated alcohol consumption of minors and young adults (Jones & Reis, 2012; Kuntsche et al., 2006; Metzner & Kraus, 2008; S. Müller et al., 2010; Wicki et al., 2006).

When considering the effects of different forms of regulation, the effects might not be exclusively related to the actual content of the regulation. One such effect, that was not covered in this analysis is from the structure of economic agents and their associated effects on future regulatory development in a potential post-regulatory-change setting. Industry influence on policy making is not a novel idea and has been extensively researched for other forms of addictive substances and behaviours. Alcohol taxation and policy (Adams, 2016; Hawkins & Holden, 2014; Kypri et al., 2019; Lyness & McCambridge, 2014), tobacco (Adams, 2016; Arno et al., 1996; Barnoya & Glantz, 2002; Ikegwuonu et al., 2021;

Jacobson et al., 1997; Kypri et al., 2019; Lyness & McCambridge, 2014; Ulucanlar et al., 2014) and gambling (Adams, 2016; Adams et al., 2021; Kypri et al., 2019) as well as prescription drugs (Abraham et al., 2002). All have had significant issues related to the rise of collective and/or concerted industry influence on policy setting. There is no reason to assume this would be any different for cannabis. In fact, when looking at preliminary developments in other jurisdictions that have already changed regulation or are considering it, industry influence is already apparent (Adams et al., 2021; European Monitoring Centre for Drugs and Drug Addiction, 2020a; Gornall, 2020; Room, 2014; Rychert & Wilkins, 2020a; Subritzky, Lenton, et al., 2016). When thinking about regulatory changes, it is therefore important to not only consider what aspects are effectively regulated, but also to think about the post-regulation stakeholder structure and potential impact on future regulatory changes (Rychert & Wilkins, 2020b). One way to anticipate and potentially prevent such effects is by considering dynamic adaption of regulation in the initial change, e.g. by creating a flexible tax system that can account for market changes without explicit regulatory change (see Caulkins, 2017).

A similar, political and social dimension was brought up by Becker et al. (2004) who investigated the positive and normative effects of regulatory regimes, which punish production and consumption of particular goods, particularly for the U.S. context. They tried to establish a "*basic theory of enforcement*" (p. 2) including government, suppliers, and consumers as individual actors, and by accounting in particular for different price elasticity in the market for illegal drugs. They try to answer the question under which circumstances a prohibit-and-enforce approach is economically more efficient than a legalise-and-tax approach. Their conclusion depends upon the ratio between the social and private value of the illegal goods. If the private value exceeds the social value, a taxation of differences in valuation would yield the economically efficient solution (p. 30). The reason this discrepancy between theoretically ideal and de-facto applied policy, they argue, lies in the differing impact of consumption on lower vs. middle/high income households. They conclude that a prohibitive regime that punishes suppliers (dealer/producer) by imprisonment and other sentences reduces consumption of higher income persons *more* than of lower income persons since it is *costlier for higher income persons* when considering the opportunity costs in the legal sector (p. 32). Following their argumentation, the resulting policy situation rests on the assumption that political clout in the U.S. is derived primarily from middle and high-income persons (as Gilens & Page [2014] suggested for example) and that there is an income-independent assumed desire to discourage children, friends, and families from drug use (or other illegal activities such as prostitution or gambling). These distributional effects of cannabis (or drug) regulation and their associated impacts on social justice have received extensive attention in recent years, particularly in the U.S.[94] Snapp & Valderrábano (2020), for example, investigate the structural issues in discriminatory and discretional applications of enforcement, while Adinoff & Reiman (2019) worked on the effects of expungement of arrests and convictions, Furman & Middleton (2020) address the legacy of the "war on drugs" that disproportionately affects minorities through mass incarcerations and the associated effects on educational attainment, lifetime income, health, etc. Harris & Martin (2021) on the other hand deal with the continuous racial disparities in post-legalized states. They investigate the licensing process for cannabis, the enforcement of remaining cannabis laws and the distribution of legal retail outlets and find that there are strong racial discrepancies in enforcement: "*Marijuana law enforcement has always disproportionately impacted people of color, a pattern that continues despite reform*" (ibid., p. 9). The same holds true for the participation of minorities in the newly regulated cannabis industry.

While this issue was not specifically addressed in this project, questions of social justice, distributional questions, and the effects of regulation and regulatory change on minorities also plays a role, as cannabis consumption and trade is not equally distributed in the population.

[94] See (Bender, 2016) for an overview on the history of race and cannabis.

While this issue was not specifically addressed in this project, questions of social justice, distributional questions and the effects of regulation and regulatory change on minorities also play a role in Switzerland, as cannabis consumption and trade is not equally distributed in the population. Using not only aggregated statistics, but also paying attention to the demographic variables behind the data is a necessary step in considering alternative regulation.

One topic that was addressed in the estimated scenarios, but omitted in the analysis, is regulatory evasion. While there are multiple forms of regulatory evasion that would have effects on both the economic impact as well as on the aims of public-health regulation. One of these, tax evasion, is of particular economic importance. Any form of product specific taxation that leads to tax-inflated retail prices creates an incentive structure for avoiding or evading these taxes. As a rule of thumb, the higher the tax, the larger the incentive to avoid/evade (G. S. Becker et al., 2004; Christie & Holzner, 2006). This can happen on various levels (production, import, wholesale- or retail) and depends largely on the exact form of taxation. Generally, there are two forms of this: legal tax avoidance (such as duty-free shops) and illegal forms (such as smuggling and selling on an illicit market). There is extensive research on the topic from experiences with different types of "sin-taxes" worldwide that are partially transferable to the debate for cannabis (Chaloupka, 2012; Chaloupka et al., 2011, 2012; Christie & Holzner, 2006; Irvine & Light, 2020; Ross et al., 2012; van Walbeek, 2010). The reason why tax evasion for excise taxes was omitted as an estimation variable is because in Switzerland this has, economically speaking, not been a large problem in recent years. As an example, the estimated consumption of beer in Switzerland for 2019 amounts to about 450m litres (Schweizer Brauerei-Verband, 2020), for wine about 255m litres (Federal Office for Agriculture FOAG, 2020b) and for spirits and liquors 122m litres (Spiritsuisse, 2017). Assuming average prices of 10 CHF/l for wine, 3 CHF/l for beer and 10 CHF/l for spirits and liquor the estimated revenue is well over 7bn CHF annually. For cigarettes, the retail market encompasses close to 9bn cigarettes sold (Federal Customs Administration FCA, 2020b). For 20 cigarettes a pack at about 8.60 CHF/pack this yields an estimated retail value of close to 4bn CHF. In contrast to the market size, the estimated import value for alcohol and tobacco smuggled into Switzerland is of negligible importance, when compared to the revenue in the retail-market (A.-F. Pilloud, personal communication, 27 February 2019). However, the larger the tax, the larger the incentive for avoidance/evasion. If cannabis were taxed significantly higher, more so than alcohol or tobacco (see for example the stylized High-Regulation scenario in chapter 5.3), tax avoidance and evasion might be a more serious issue, especially given the pre-existing and dynamic illicit market in both Switzerland and surrounding countries, and the low threshold for a legal premium for very frequent consumers (see Figure 22). Another factor to consider in the short run is that there might be trade-offs between different regulatory aims (e.g. displacing the illicit market through pricing mechanisms vs. setting a price-floor as a form of preventive measure; see Childs & Stevens, 2021)

Other issues, such as the emergence or growth of a potential grey-market (e.g. due to secondary sales to minors, or by re-selling CSC cannabis in the CSC scenario), evasion or product quality regulation by producers, or tax avoidance through transfer pricing in vertically integrated firms also fall into this category. However, these effects depend on the specific form of regulation, the actual implementation, and the enforcement of said regulation and are likely of lesser economic importance in the short term. This does not mean they are trivial. On the contrary, if a form of regulation by design or by lack of enforcement leads to a decrease of the age-of-onset or an increase in use by minors and adolescents this might not mean much in terms of market relevance in the short term, but it could have significant effects with respect to social costs (healthcare, lifetime educational and economic attainment, etc.) in the long-term (Vogel et al., 2019).

Similar medium-to-long term effects could be expected from changes in social norms and perceived risks of cannabis consumption. Miech et al. (2015) for example show, that from 2007 to 2013 (cannabis decriminalised in California in 2010), "*12th graders as* *compared to their peers in other states became […] 20% less likely to perceive regular marijuana use as a great health risk […]*" (p. 1). Similar results were found in Colorado in an analysis for 2003-2011.Schuermeyer et al. (2014) find: *"The perceived risk of using marijuana has decreased in recent years in Colorado. In some instances this appeared prior to 2009 (e.g., "no-risk" among young adults, 18–25 year olds), but in others there appears to have been a change in Colorado around 2009. For example, perception of "great-risk" decreased between 2007–8 and 2009–10 for other adults (26 years old or older) from 45% to 31%"* (p. 7). To what extend these changes in perceived risk are attributable to regulatory change either of medicinal cannabis regulation or recreational, remains open for investigation. Some preliminary findings are noted by Wen et al. (2019) for example who "*found that state implementation of medical marijuana laws between 2004 and 2012 was associated with a 4.72% point increase (95% CI 0.15, 9.28) in the probability that young adults perceived no/low health risk related to marijuana use"* (p. 215), and Keyes et al. (2016) note: "*perceived harmfulness of marijuana use appears to be decreasing nationally among adolescents in the United States, the passage of medical marijuana laws (MML) is associated with increases in perceived harmfulness among young adolescents […]*" (p. 5). Such changes in the attitudes toward cannabis risk, cannabis consumption, etc. arecore issues to consider when considering regulatory changes, as they are directly related to changes in behaviour. Pacula et al. (2009), based on U.S. Data for example "*suggest that a 10 percent decrease in the perceived harm of marijuana would generate a 28.7 percent increase in annual prevalence of marijuana use among youth*".

Finally, for the estimation conducted in this project the cannabis system was treated as an isolated economic system. In reality, this is not the case. There is strong empirical evidence that cannabis consumption is linked to the consumption of other psychoactive substances such as tobacco, alcohol and other, illicit substances both in Switzerland and in other countries (Banks et al., 2019; Gmel et al., 2017; Jordan et al., 2018; J. H. Kim et al., 2021; Lanza et al., 2021; Rumpf et al., 2016). There is also some empirical evidence, that a regulatory change for cannabis leads to a decrease in the use of prescription drugs (e.g. for chronic pain) (Bradford & Bradford, 2016; Cerdá et al., 2012; Corroon et al., 2017; Lucas et al., 2013, 2019). These aspects are relevant from an economic perspective because changes in cannabis consumption will likely not only change the cannabis market, but also change the demand for other substances, one way or the other. The evidence on whether the relation of cannabis to other psychoactive substances is substitutionary (e.g. consumers choose cannabis rather than other substances) or complementary (consumption changes in cannabis also change the consumption of other substances in the same direction) is however inconclusive and seems to depend on a number of contextual factors (consumer type, substance, taxation, age-group, etc.) (Cameron & Williams, 2001; Lucas et al., 2013, 2019; Reiman, 2009; Risso et al., 2020; Subbaraman, 2016; J. Williams & Mahmoudi, 2004). Regardless of the insights from future research on the relation between cannabis consumption and the consumption of other substances, it is important to consider, that the economic effects of regulatory change for cannabis are not isolated to the cannabis system itself. Regulation will have effects on the consumption of other substances as well. These effects need to be taken into account when considering more specific forms of regulation depending on whether they serve the intended goal of regulatory change.

Two theories compete for the explanation of developing drug usage. The gateway hypothesis (GH) postulates that there is a *causal* relationship between the usage of different "stages" of drugs. The competing theory called "common liability to addiction" (CLA) argues that both sequential or co-occurring usage of different drugs is primarily based in genetics and can be attributed to common reasons for addictive behaviour. Evidence for the gateway hypothesis has been mixed over the decades (Degenhardt et al., 2010; Guxens et al., 2007; Kandel, 1975; Nkansah-Amankra & Minelli, 2016; Vanyukov et al., 2012). One review of the theoretical and empirical findings of both hypothesis by Vanyukov et al. (2012) concludes: "*Juxtaposed with the parsimonious and empirically proven concept of CLA, explaining comorbidity of substance use disorders and polydrug abuse by commonality in etiologic mechanisms, the GH appears redundant*" (p. 514).

7.2 CONCLUSION

In this final chapter of the report, it is time to look back at the originally posed research questions and determine, what this project contributed to answering them:

- What are the total economic effects on both the direct and indirect levels triggered by the cannabis system in the Swiss economy?
- How are these effects split between different actors, processes, and legal and illegal activity?
- What are relevant economic regulatory variables for recreational cannabis and what are the extents of their effects when combined in regulatory scenarios?

In the analysis of the cannabis system in Chapter 3 and Chapter 4 I compiled the available data to answer the first two of these questions for direct and indirect economic effects. Total gross output (direct and indirect) for the entire cannabis system under the current regulation amounts to about 1b CHF annually. The largest share (84%) of total gross output by far is triggered by illegal activity in the cannabis market. Economic effects by legal activity in the other segments of the cannabis system (e.g. healthcare and police work) make up the remaining 16% of total economic effects.

The analysis has thus shown that the current regulation creates an outcome, where illegal economic activity in the production import and trade of cannabis can generate significant economic returns for the involved actors. The illegality of the market activity has several effects. On the one hand, a significant part of the cannabis value-chain is located outside of Switzerland and thus beyond the reach of immediate regulatory and fiscal access. On the other hand, the illegal economic activity located within Switzerland is part of the shadow economy, as it is actively hidden, due to the associated legal repercussions. This in turn deprives public authorities, except for policing, from any form of market access in both regulatory and fiscal capacities (e.g. concerning consumption interventions or product quality). In effect the current regulation fosters a self-regulating, hidden market of domestic and international actors profiting from inflated profit margins caused by the illegality of cannabis. As can be expected, public-health aims, such as responsible consumption, youth prevention or transparent product quality/potency, play little to no role in this market.

How the status quo could change, was shown in Chapter 5. To do so stylized alternate forms of regulation were devised based on international experiences and academic literature with respect to regulatory and fiscal market access. The simulation of the economic effects shows that the total gross output of the cannabis market could drop from about 840m CHF annually in the status quo to just about 130m CHF in the Free-Market scenario. The Cannabis Social Club scenario would amount to about 580m CHF and the High-Regulation scenario would come it at about 230m CHF. In summary this means that economic regulation can significantly influence the profitability of the cannabis market as well as the ratio between private and public gains. The latter is influenced both by the fiscal access to economic activity (legal vs. illegal activity) as well as by different forms of taxation that can be applied (see Chapter 5).

The different taxation schemes that were simulated affect not only the tax revenue generated by public authorities (between 464m CHF in the High-Regulation scenario and 12m CHF in the Free-Market scenario) but can also be used as a steering tool for actively shaping market outcomes (e.g. by influencing product prices). Fiscal access to market activity thus allows public authorities to internalise some of the societal externalities of cannabis consumption through taxation in the classical pigouvian sense (Pigou, 1929; Coase, 1960; Cornes & Sandler, 1996). These taxes can be tied to specific public-health oriented activities and/or be redirected to finance societal costs associated with cannabis consumption. The outcome of such change would thus allow to actively reduce the costs to society by prevention and adequate social- and healthcare-interventions as well as make the cannabis system more economically just in the sense of a cost-by-cause principle.[95]

By addressing the research questions this thesis provides new insights that were previously not addressed in the existing literature. The construction of the cannabis system by drawing together economic activity in different industries in Switzerland using the perspective of economic activity as a whole has previously not been available. The quantitative analysis of each of the segments including the modelling and estimation of indirect economic effects using a cannabis specific IOT based model provides for the first time an answer to the question of how much economic activity is actually connected to the current form of cannabis regulation in Switzerland. By using an approach in line with national accounting standards, the analysis conducted in this thesis has been the basis for the partial revision of Swiss GDP calculation including illegal economic activity such as drug trafficking. Using this basis for the simulation of stylized regulatory scenarios reveals additional insights into the economic effects of regulatory variables and thus provides crucial information previously unavailable.

7.3 Limitations, challenges, and future research

Empirical research in illegal social phenomenon is notoriously plagued by a host of methodological problems, data availability and limits to data gathering being among the most prominent. This issue has also been the central challenge throughout this project. While applied empirical research has been at the centre of my professional career for more than a decade, no project I have dealt with so far has posed similar data-related challenges. Due to the illegality of recreational cannabis in Switzerland, the data and research on the topic domestically is limited. This situation is similar internationally (Singleton et al., 2018). Throughout the project I

[95] This assumes that potential additional burdens of alternate regulation do not exceed these distributional effects.

have thus learned that empirical research in illegal phenomenon is seldom straightforward and often takes convoluted paths and requires creativity, perseverance, and a generous dose of open-mindedness for alternative approaches. When interpreting the results of this project, it is thus important to keep in mind that any estimation is only as good as the data it is based on.

Specific issues with individual topics and/or data sources are discussed in each chapter to allow future research to enhance specific aspects of this project. In particular, the following topics ought to be researched further, as more data becomes available, to improve the calculations made in this report:

- Continuous monitoring of prevalence data, consumption behaviour, potency as well as trade-related information such as transactional data
- Improvements in the methodology and widespread application of waste-water-analysis for improved correction of survey-based under-reporting the substance-specific case and care costs in the healthcare system (including mental-health focused institutions)
- The substance-specific costs for penalty enforcement in the judicial system

It is important to keep in mind that the results of this project do not provide a detailed answer to the question of how cannabis should be regulated from an economic perspective. This is because there can be no clear-cut answer, as it depends on both the context of the regulatory change, the previous regulatory situation, and most importantly the intended goals of a change in regulation. The project has shown instead that different perspectives on cannabis regulation, including economics, are closely intertwined. How cannabis ought to be regulated should not be a debate based primarily on economic considerations anyhow. This much can be inferred, when considering the experiences in other jurisdictions, especially in the U.S. (see Subritzky, Pettigrew, et al., 2016). On the contrary, there are a multitude of additional aspects to consider. One approach to structure the discussion on this topic was provided by Rogeberg et al. (2018). They distinguish seven different clusters ranging from health and social aspects to political issues and economic questions. For Switzerland Anderfuhren-Biget et al. (2018) provided suggestions for regulatory variables that ought to be considered.

In a way, many of the aspects in this analysis – and the conclusions drawn from them – are not only related to cannabis. They can be transferred to an overarching discussion about the general question of how psychoactive substances, which are currently classified as illegal drugs, should be regulated in a society. The economic working mechanisms behind illicit market created by prohibition are similar, even if the substance under discussion is different in nature. A case in point are the analysis conducted by Addiction Suisse on the opioid and cocaine markets in the canton of Vaud (Zobel, Esseiva, et al., 2017; Zobel et al., 2018) that show similarly developed illegal market structures in other drug markets. Based on decades of experiences, developing a coherent and effective way of regulating psychoactive substances that relies on rational and evidence-based criteria remains an open task for policy makers in Switzerland (Cattacin & Domenig, 2015; Eidgenössische Kommision für Drogenfragen, 2005).

When considering how to best achieve regulatory goals, economic considerations are important because they can help to achieve the goals of non-economic regulatory variables. The economic perspective is thus less of a goal itself, but rather a tool that can help to shape a sensible approach to regulating cannabis to minimize its adverse social and health effects and to protect particularly vulnerable segments of the population.

This project was conducted between 2018 and 2021 and as can be discerned from the dates of the cited literature, in this timeframe, there has been a continuous flow of newly published findings from around the world. With only a few cases worldwide where regulation on cannabis has changed, the empirical data available to study the effects of regulatory changes is sparse and – so far – often inconclusive or even contradictory. Regulatory changes have occurred only in the last few years and many effects have not yet fully materialised. In addition, data availability both pre- and post-regulatory change has acute limitations.

The information in this report thus ought to encourage policy makers to not only consider how to regulate cannabis, but in the spirit of evidence-based policy making also to consider how to evaluate and improve said regulation in the future. It is important to underscore that this does not only concern future data and research *after* regulatory change, but also a thorough and detailed understanding of the situation of the cannabis system *pre*-regulatory change. If data on either side is limited inferring causality and thus learning for future regulatory decisions will be a challenging task (Wardle, 2018; Yates & Speer, 2018).

This project has quantified the economic effects associated with the cannabis system in Switzerland and has simulated the economic working mechanisms and effects of stylized alternate regulatory scenarios. By doing so I have tried to add to filling the identified research gap concerning the economic side of the cannabis system in Switzerland and provide a contribution for policy makers, the interested public, and for future research on the topic. I hope that the information provided in this report will enrich the ongoing public debate by providing insight into the possibilities and limitations of economic regulatory effects of cannabis regulation in Switzerland.

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Annex

Questionnaire police interviews

Products and markets

1. Which cannabis products play the largest role in your city/your canton?
2. Is there a significant usage/trade of resin?
3. Is it possible to estimate the market share of marijuana?
4. How has the potency of cannabis products in your jurisdiction developed in recent years?
5. Where does the cannabis in your city/canton come from? Are significant amounts imported? Does this differ between products?
6. Is there a notable local/regional production of cannabis?
7. If yes, which production forms are most common? Indoor/Outdoor? Small/Large?
8. What demographics are mostly active in the production of cannabis?
9. What demographics are mostly active in the trade of cannabis?
10. Can you describe the cannabis market structure in your city/canton to me? Are these many, heterogeneous different actors, single large networks?

11. Do production and trade often happen in the same organisation?

12. How would you describe the relationship between the cannabis market and the markets for other illegal substances? Are these separate or is there overlap?

13. Are there overlaps in the markets of CBD and non-CBD cannabis in your city/canton?

14. What are the prices that are paid for the different cannabis products "on the street" in your city/canton?

15. What are the prices that are paid for the different cannabis products at wholesale level in your city/canton?

16. Do you have any information on the import value of cannabis products?

17. Can you explain to me where the seizures of the PKS mostly come from? Can you estimate, what type of seizures have already been traded at retail value?

POLICE ACTIVITIES AND RESOURCES

18. Can you describe to me the organisational structure in your corps? Who is working on narcotics related issues?

19. Are there other organisations, next to your unit, who are working on cannabis related issues within the cantonal police?

20. Can you describe to me what tasks lie with the city police and which tasks with the cantonal police?

21. My aim is to estimate the resources required by the police annually for cannabis related workflows. Which indicators do you think are most helpful in estimating this?

    a. FTEs of the relevant personnel/units?

b. Reported crimes?

c. Number of controls, seizures, etc.?

d. Others?

22. Are the resources that you require for cannabis related workflows relatively stable, or have there been significant changes over the years?

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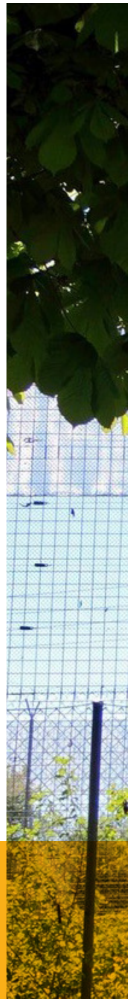

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