PARETO

Undergraduate Journal of New Economists

University of Toronto Mississauga

Title:	Effects of Cannabis Legalization on Tobacco and Alcohol Prevalence
Author:	Gregory Chung
Source:	*PARETO: Undergraduate Journal of New Economists*, Vol. 1, Winter 2023
Published By:	Department of Economics, University of Toronto Mississauga
Stable URL:	https://www.uecutm.ca/pareto-chung2023

Economics

UNIVERSITY OF TORONTO

MISSISSAUGA

Effects of Cannabis Legalization on Tobacco and Alcohol Prevalence

By Gregory Chung

This paper investigates the potential links between cannabis legalization and the use of other substances in the United States. In particular, it tests for changes in the prevalence of tobacco and alcohol use following cannabis legalization (Medical or recreational). This study is carried out on all 50 American states using a difference-in-differences estimator with data running from 2012 to 2018. It finds a significant decrease in tobacco use as a result of cannabis legalization. However, no statistically significant change in trend is observed in the prevalence of alcohol use following cannabis legalization.

***Keywords**: Cannabis use, drug policy, difference-in-differences, fixed effects analysis, panel data*

I. Introduction

Cannabis is the most widely used illicit drug in the USA (NSDUH statistics, 2018) with approximately 52 percent of all Americans aged 18 or older reporting having used it at least once (NBC News, 2017). The legalization of cannabis has been a hot topic during the past 10 years. Although cannabis use has remained illegal at the country/federal level since the 1930s in the United States, there are many individual states that have passed new legislation regarding the substance. This legislation ranges from the removal or reduction of criminal penalties (decriminalization) to complete legalization including commercial sales. As of April 2020, there are 39 states, including the District of Columbia, that have at least legalized the use of cannabis for medical purposes (see appendix figure A1 for breakdown). State legalization is on the rise for recreational cannabis as well [State Policies Department (2020)].

With these facts comes an important question: what is the relationship between the legalization of cannabis and the prevalence of tobacco and alcohol use? Relatively few studies have investigated this topic in the US. This research aims to add to the literature by attempting to evaluate the effects of the legalization of cannabis on tobacco and alcohol prevalence in the 50 states of the US and the District of Columbia. In particular, this paper will ask whether there is any complementarity or substitutability between cannabis and the use of tobacco or alcohol?

Being able to determine a relationship between cannabis and tobacco or alcohol could provide insights in developing policies relating to taxation, regulation and even pricing [Caulkins (2012)]. An early study conducted in Australia on cannabis, tobacco and alcohol, using data from the National Drug Strategy Household Surveys (NDSHS), found that cannabis and tobacco were complements [Cameron and Williams (2001)]. This paper aims to carry out a similar study using addiction data for the United States. This is relevant as it might inform policy regarding future legalization. If a link is found then policy targeted towards one substance might indirectly affect

demand for the other.

The rest of the paper will proceed as follows. Section 2 discusses the relevance of the topic and the extant literature, section 3 reviews data and methodology, section 4 presents the results, interpretation of coefficients and discusses the endogeneity issues and robustness of the model while section 5 concludes the paper.

II. The Extant Literature

There is a plethora of literature that aims to uncover the various implications of cannabis legalization. Studies range from estimating the health impacts of the substance to understanding the potential psychological and economic relationships cannabis has with other substances like alcohol and tobacco. In the latter case, investigations were carried out in an attempt to help decision makers devise proper regulatory policies to control a substance that was once illegal. These economic studies range from estimating the size of the black/illegal market to determining the price elasticity and degree of substitutability between legal and illegal cannabis [Amlung et al. (2019)]. Some studies have also attempted to estimate the substitutability with respect to alcohol and tobacco [Cameron and Williams (2001)].

Another relevant study was carried out in Switzerland to understand cannabis consumption modes amongst adolescents [Akre et al. (2009)]. A qualitative approach was adopted to identify cannabis and tobacco co-consumption and consumers perceptions of each substance. Five focus groups consisting of 22 youths (14 males) in the age group 15-21 years were interviewed seven times individually. Interestingly, this paper found that cannabis was perceived more positively than tobacco and therefore was considered a substitute to the latter. However, despite the perceived substitutability, the paper concluded that cannabis consumption could still induce nicotine dependence and cigarette smoking. It was thus recommended that the relationship between both substances was taken into consideration when implementing prevention programs.

A different conclusion was reached by [Cameron and Williams (2001)]. This study used individual level data for the years 1988, 1991, 1993 and 1995 from the National Drug Strategy Household Survey alongside alcohol and tobacco price indices from the Australian Bureau of Statistics. The data was pooled, leading to a sample size of 9744 observations. The study concluded that cannabis and tobacco were complements, while alcohol and cannabis were substitutes. A key aspect of the study was that participation in all 3 drugs was sensitive to own price changes and that decriminalization of cannabis resulted in an increase in its consumption.

One possible factor that could account for the discrepancy in the findings is related to the type of data collected. As mentioned by [Verbic et al. (2001)], the majority of studies use general population surveys for estimating the prevalence of cannabis. Some authors have argued that this type of data has a drawback of not being able to reach the cannabis-using population because of users unwillingness to report their true conditions due to fear of stigmatization [Fendrich and Johnson (2005)]. Other researchers favour the use of information collected from the household population surveys in understanding marijuana markets [Caulkins and Pacula (2016)].

The lack of reliable price data for cannabis also hampers empirical estimation of price responsiveness. Economists have tried to estimate price elasticity wherever price data were available. Since available prices are not always idiosyncratic, estimated price effects differ broadly across studies. Due to the inexistence of data on quantities consumed, price elasticities are generally

reported in terms of participation probability (as cited in Verbic et al, 2019).

A recent study, conducted by [Veligati et al. (2020)] in the US, investigated the impact of the legalization of medical and recreational cannabis on state-level per capita alcohol and cigarette consumption. The authors used data from state tax receipts maintained by the Centers for Disease Control and National Institute for Alcohol Abuse and Alcoholism with a difference-in-differences estimator. One strength of this paper was the use of a 3-tiered model that included different covariates to mimic the differences in medical and recreational legislations across states. The authors found no significant relationships between medical or recreational cannabis policies and per capita sales of cigarettes and alcohol.

While most economic studies on the topic used data on economic variables (such as prices, sales and taxes), relatively few of them used data on the actual number of people consuming the substances. Therefore, this paper aims to carry out a similar study to [Veligati et al. (2020)] with a difference-in-differences method, but using a drugs prevalence data set for the US.

III. Data & Methods

A. Data Summary

Following [Caulkins and Pacula (2016)] this paper focuses on household substance use. Specifically, this paper employs household data obtained from the Substance Abuse and Mental Health Service Administration (SAMHSA) website, which operates under the US Department of Health Human services. The data set consists of seven yearly iterations of the National Survey on Drug Abuse and Health (NSDUH) data over the period 2012 to 2018 for all of the 51 states. The data were collected from a sample of individuals who have a tendency towards addiction. Tobacco prevalence in our data set is defined as the number of people (in thousands) having reported consuming cigarettes, smokeless tobacco (i.e., snuff, dip, chewing tobacco, or "snus"), cigars, or pipe tobacco for an amount of at least 100 cigarettes in their lifetime. Alcohol prevalence includes the number of people (in thousands) having reported consuming at least a full drink in the past 30 days. Given the approach taken in this paper, the age group 26 and older will be the group of interest. Table 1 provides a summary of the data for the age category of interest.

B. Survey Breakdown

Data used in this study was obtained from an annual household interview survey of substance use, substance use disorders, mental health and the receipt of treatment services for the disorders (see appendix figure A2 for the survey front page). The survey is targeted towards non-institutionalized individuals of age 12 years and older. In particular, the survey measures the average prevalence of drug and substance use at the state level for the following age groups: 12-18, 19-25 and 26 and above. Responses from approximately 67500 households are recorded annually. The survey is a cross-sectional one, carried out each year (on different households).

An interesting trend can be immediately observed in these statistics. The mean cannabis prevalence is lower for states where the substance is legal than for states where it is illegal. A potential explanation for this observation is the control of quantity and hoarding effect. When cannabis is illegal, (the supply of the substance is very low), people tend to consume more of it and stock it up. Conversely, in states where the supply is higher (coming from the legalization),

people no longer have the need to hoard. Another reason might be the "criminality effect" as put forward by Becker, Murphy and Grossman in their paper "The Economic Theory of Illegal Goods: The Case of Drugs" [Becker et al. (2006)]. According to Becker, legal taxation on producers may be more effective than enforcement of illegal drugs in reducing consumption. The survey data does reveal higher mean for first time use of cannabis for legal states. Intuitively, once cannabis is available through various point of sales (POS), it is easier to access leading to greater first time use. However, the mean use of cannabis overall is not significantly different from legal to illegal states. Difference of means testing for each type of substance use (cannabis, alcohol and tobacco) does not reveal a statistically significant difference amongst states where cannabis is legal vs. ones where it is illegal. Hence, the descriptive statistics do not provide a clear picture on the causality between prevalence and legalization but signal some potential links (for example with average first use being much higher in states that have legalized).

Table 1—Summary statistics on prevalence (000s) for the group 26 years and older

	Illegal (N=84)				**Legal (N=273)**			
	Mean	sd	Min	Max	Mean	sd	Min	Max
Cannabis	269.869	221.717	13	829	265.205	364.052	17	2676
Alcohol	2357.464	2210.118	197	8941	2219.033	2593.35	253	14513
Tobacco	1181.988	994.183	103	4189	963.267	963.772	101	4538
First time	4.036	3.254	0	15	8.381	11.089	0	96

C. Methodology

The repeat cross-sectional surveys do not allow for estimation of within-individual household changes in outcomes over time. Analysis therefore must focus on estimating outcomes averaged across states, and in comparing changes in these over time between 2012 and 2018. This paper assumes that determinants other than the legalization of cannabis remained stable in the fifty states over time or followed a parallel change. Given this assumption, a difference-in-differences (DID) analysis can be used to uncover the average net effect of the legalization on tobacco prevalence amongst individuals age 26 or above.

Basically, the DID estimator can be calculated as:

$$y_{\text{DID}} = (y^{\text{L}}_{\text{AL}} - y^{\text{L}}_{\text{BL}}) - (y^{\text{I}}_{\text{AL}} - y^{\text{I}}_{\text{BL}})$$

Where superscript L and I refer to the states where cannabis is legal and illegal respectively and subscript AL is the time period after the legalization while BL is before legalization.

The use of Pooled OLS (POLS) to calculate the DID estimator is justified because of the repeated cross-sectional nature of the survey. The sampling technique was designed so that no overlap amongst residents was expected. The only way overlap could happen was if the individuals moved to another area segment/state in-between years and their new residence was selected again the following year for the survey. By design, panel data techniques are not

necessarily required. A Breusch-Pagan test was used to identify any issues and help with model selection. According to the test, the null hypothesis is constant variance (homoskedasticity) within the sample. The test results indicate there was no statistical evidence at the 5% level to reject the null. For the main approach in this study, panel data methods were discarded and the POLS model was selected.

Although the Breusch-Pagan test did not detect any issue of heteroskedasticity in the sample, the model was also estimated on the full sample using a panel data treatment to account for unobserved heterogeneity and test for the robustness of the POLS estimation. The Hausman test was used to determine between either a random effects or a fixed effects estimation technique. Recall that the null hypothesis for the test is that a RE model is consistent and preferred. Test results indicated that there was evidence to reject the null, so that a FE model was chosen, in addition to the main model estimated. Test results relating to model selection are available on request.

The basic DID coefficient (Y_DID) is estimated by the following equation using Pooled Ordinary Least Squares:

$$\begin{aligned} ln\text{Tobacco}_{\text{it}} = \beta_0 + \gamma\text{Legal}_{\text{i}} + \theta\text{AfterYear}_{\text{t}} + \delta(\text{Legal} * \text{AfterYear}_{\text{it}}) + \\ \eta\text{Recreational}_{\text{i}} + \phi\text{Decriminalized}_{\text{i}} + \varepsilon \end{aligned}$$

The outcome variable $ln\text{Tobacco}_{\text{it}}$ is the natural logarithm of tobacco prevalence, Legal_{i} is a dummy for the treatment (legalization) effect, $\text{AfterYear}_{\text{t}}$ is a time dummy to indicate whether an observation occurs after the legalization and $(\text{Legal} * \text{AfterYear})$ is an interaction term that gives the average treatment effect. Before going any further, it is important to define what is meant by legalization here. In the regressions, 'Legal' is a dummy variable that refers to cannabis being legal for either medical or recreational use. In fact, if a state legalizes the substance for recreational purposes, it automatically means that it is legal for medical use. A recreational use dummy is used to capture the effect of a full legalization for recreational purposes. Many states have ideosyncratic policies with regard to the legality of cannabis. There is a spectrum of legislations between illegal and legal. To account for this, we also include a state dummy for decriminalized (possession of cannabis not seen as a criminal offence).

For the sake of specification and statistical relevance, it is also important to account for both state and year fixed effects. Economically, having state fixed effects helps to control for the possible unobserved heterogeneity such as varying state legislations that affects prevalence/use of the drug amongst households within a particular state. Year fixed effects are expected to capture unobserved heterogeneity in a particular year. λ_{i} captures the state fixed effects while μ_{i} captures time fixed effects. One advantage of the DID method is that it mimics an experimental research design by designating a treatment and control group using observational data. The model can also allow for dummies/covariates to be included to account for the different directions and characteristics the two groups can take.

The adjusted fixed effects Pooled OLS is now:

$$\begin{aligned} ln\text{Tobacco}_{\text{it}} = \beta_0 + \gamma\text{Legal}_{\text{i}} + \theta\text{AfterYear}_{\text{t}} + \delta(\text{Legal} * \text{AfterYear}_{\text{it}}) + \\ \eta\text{Recreational}_{\text{i}} + \phi\text{Decriminalized}_{\text{i}} + \lambda_{\text{i}} + \mu_{\text{t}} + \varepsilon \end{aligned}$$

Where the treatment group is defined as states that have legalized cannabis prior to 2018 and the control group consists of those states where cannabis is still illegal. To evaluate the specification of the model after the inclusion of these additional covariates, a Ramsey Regression Equation Specification Error Test (RESET) was used. The test found no evidence at the 5% level to reject the null and concluded that the model is well specified.

IV. Results

A. Full Sample Specification

The results of the regressions are shown in Table 2. To facilitate the interpretation of coefficients, we make use of a log-level model. The coefficients of the dependent variables are interpreted as a $100 * (e^{\beta} - 1)$ percentage change in average tobacco prevalence. Keeping all else constant, being a legal state increases tobacco prevalence by approximately 1.37%. This coefficient is not significant. The coefficient of the dummy for recreational legalization says that the average tobacco prevalence decreases by 52.3% if a state fully legalizes cannabis for recreational purposes. Conversely, states where the recreational use of cannabis is decriminalized (not a criminal offence) are likely to experience a rise of 5.8% in the average prevalence of Tobacco. Both coefficients are statistically significant at the 1% level.

Our main coefficient of interest, DID (which is the average net treatment effect), is calculated by taking an unweighted average of all the DID coefficients from the years 2012 to 2017. The resulting average is -0.0084482. Given individual significance tests for each coefficient we can conclude that the average DID effect is significant at the 5% level. This means that on average over the 6 years (excluding 2018 because of no post 2018 data), average tobacco prevalence fell by 0.845% as a result of the legalization of cannabis, for either medical or recreational use.

Next we apply the same model using average alcohol prevalence as the dependent variable. We find that when a state is legal, there is an approximate increase of 73.3% in the average alcohol prevalence and this is significant at the 1% level. Similar to the estimations on tobacco, decriminalizing cannabis has a positive effect on the average Alcohol prevalence. In fact, there is an approximate increase of 93.9%. The coefficient on the recreational legalization measure points towards a 79.8% fall in alcohol prevalence as a result of legalizing cannabis for recreational use and is statistically significant at the 1% level.

Following the same averaging process in the case of tobacco prevalence, we obtain that the average net treatment effect over the time period 2012 to 2018 is a decrease of 0.3% in alcohol prevalence. Unlike the calculated average from the tobacco regression, it is not statistically significant for alcohol. The reported R-squared values are 0.99 for both the tobacco and alcohol regressions, indicating a very good fit but potentially the presence of some specification issues or multicollinearity.

These results seem to point towards a substitution away from tobacco products resulting from the legalization of cannabis for either medical or recreational use. However, the same causal relationship cannot be established for alcohol.

Table 2—Results: Full sample

	(1) Tobacco	(2) Alcohol
Legal	0.0137	0.553***
	(0.0203)	(0.0194)
DID12	0.00614	0.00163
	(0.0213)	(0.0181)
DID13	-0.0128	-0.00760
	(0.0196)	(0.0153)
DID14	0.00381	-0.00653
	(0.0196)	(0.0123)
DID15	0.0121	-0.0111
	(0.0210)	(0.0138)
DID16	-0.0248	-0.00261
	(0.0225)	(0.0159)
DID17	-0.0352	0.00819
	(0.0234)	(0.0173)
Recreational	-0.741***	-1.599***
	(0.0188)	(0.0146)
decriminalized	0.0580***	0.662***
	(0.0217)	(0.0216)
N	357	357
R^2	0.998	0.999

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As a final check on these results, a panel data model using FEs was estimated for the full sample. The coefficients do not change significantly and the average DID effect is still -0.00845 and is significant at the 5% level. The model did not suffer from heteroskedasticity. Table IV.A reports the detailed results of the regressions including FEs for the full sample.

Table 3—Results: Full sample Panel regression

	(1) Tobacco	(2) Alcohol
Legal	0	0
	(.)	(.)
DID12	0.00614	0.00163
	(0.0211)	(0.0148)
DID13	-0.0128	-0.00760
	(0.0211)	(0.0148)
DID14	0.00381	-0.00653
	(0.0211)	(0.0148)
DID15	0.0121	-0.0111
	(0.0211)	(0.0148)
DID16	-0.0248	-0.00261
	(0.0211)	(0.0148)
DID17	-0.0352*	0.00819
	(0.0211)	(0.0148)
Recreational	0	0
	(.)	(.)
Decriminalized	0	0
	(.)	(.)
Year and state fixed effects	Yes	Yes
N	357	357
r2_within	0.257	0.292
r2_between	0.00120	0.000146
r2_overall	0.000931	0.000238

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B. Restricted Sample Specification

To cross-check the reliability of the main methodology and evaluate the statistical significance of the DID coefficient, an alternative approach was also adopted. This method consists of pooling states into subsamples based on their respective periods of legalization. Specifically, this approach uses restricted samples of states, for each legalization year between 2012 and 2018, while excluding 2018 (no post-2018 data). The subsamples are made up of the states that legalized either medical or recreational cannabis in the years 2012 to 2017 and 12 states where cannabis remained illegal. The largest subsample is that of legalization year 2014, where the treatment group is made up of 7 states that passed new legislation in 2014. The subsample for 2016 is the second largest with 4 states in the treatment group. Subsamples 2012, 2015 and 2017 all have 3 states each in the treatment group. Finally, subsample 2013 has only 2 states that implemented new cannabis legislation.

The reported coefficients (Table 3) for 'Legal' are negative for the subsample of states with legalization year 2014, 2015 and 2016, and are all statistically significant at the 1% level. This indicates a switch away from tobacco in states that legalized cannabis for either medical or recreational use. However, this paper is mostly interested in the respective DID coefficients. It is worth noting that only the DID coefficients from legalization years 2012, 2015 and 2016 are statistically significant and represent a fall of 5.91%, 4.73% and 5.26% in the average tobacco prevalence respectively. The only positive coefficient for the interaction term is recorded in 2014 only and is insignificant.

The same approach is applied with alcohol as the dependent variable. Table 4 reports the estimated coefficients. Notice here that, once again, the only significant DID coefficients are negative. These are recorded for the years 2013, 2014 and 2015 respectively. An interesting observation is that in 2015, after legalization there is a fall in both tobacco and alcohol prevalence. This subsample included the states of Georgia, Louisiana and Texas. All three of them legalized cannabis for medical use only. Georgia and Texas had similar legislation, whereby CBD oil containing less than 5% and 0.5% THC was legalized. Hence, these were very unique legalizations and could explain outliers in the results.

This alternative approach validates what was found in the first method in the case of tobacco prevalence. There has been a substitution away from tobacco that resulted from the legalization of cannabis. The results are less clear for alcohol. Although the alternative method captured significant downward trends resulting from the legalization, no statistically significant evidence was found using the main approach. Therefore, it is difficult to claim a substitution away from alcohol.

Table 4—Restricted samples approach: Tobacco

	(1) Tobacco	(2) Tobacco	(3) Tobacco	(4) Tobacco	(5) Tobacco	(6) Tobacco
Legal	0.725***	0.170***	-2.213***	-1.196***	-1.762***	0.00695
	(0.0322)	(0.0402)	(0.0206)	(0.0310)	(0.0256)	(0.0165)
Recreational	-0.0585***	-0.0585***	-0.0585***	-0.0585***	-0.0585***	-0.0585***
	(0.0213)	(0.0196)	(0.0206)	(0.0211)	(0.0204)	(0.0201)
Decriminalized	0.0580**	0.0580**	0.0580**	0.0580**	0.0580**	0.0580**
	(0.0239)	(0.0230)	(0.0264)	(0.0238)	(0.0238)	(0.0240)
DID12	-0.0591*					
	(0.0311)					
DID13		-0.0207				
		(0.0314)				
DID14			0.00923			
			(0.0162)			
DID15				-0.0473**		
				(0.0233)		
DID16					-0.0526**	
					(0.0234)	
DID17						-0.0129
						(0.0302)
N	105	98	133	105	112	105
R^2	0.998	0.998	0.998	0.998	0.998	0.998

Robust Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5—Restricted samples approach: Alcohol

	(1) Alcohol	(2) Alcohol	(3) Alcohol	(4) Alcohol	(5) Alcohol	(6) Alcohol
Legal	0.886***	0.272***	-1.662***	-0.940***	-1.174***	0.541***
	(0.0260)	(0.0217)	(0.0166)	(0.0193)	(0.0206)	(0.0160)
Recreational	0.0766***	0.0766***	0.0766***	0.0766***	0.0766***	0.0766***
	(0.0155)	(0.0157)	(0.0157)	(0.0157)	(0.0153)	(0.0157)
Decriminalized	0.662***	0.662***	0.662***	0.662***	0.662***	0.662***
	(0.0216)	(0.0217)	(0.0210)	(0.0214)	(0.0214)	(0.0214)
DID12	-0.01000					
	(0.0282)					
DID13		-0.0667***				
		(0.0174)				
DID14			-0.0221*			
			(0.0123)			
DID15				-0.0471***		
				(0.0177)		
DID16					-0.0206	
					(0.0159)	
DID17						0.0000196
						(0.0251)
N	105	98	133	105	112	105
R^2	0.999	0.999	0.999	0.999	0.999	0.999

Robust Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

V. Conclusions

One should be careful when interpreting the results of this study. Although we found a statistically significant fall in the average tobacco prevalence resulting from new legislation on marijuana, it does not necessarily mean that both substances are economic substitutes. As mentioned earlier, different individuals have different preferences with respect to drugs. Some might be more prone to consuming cannabis because they are already consuming tobacco and vice versa. More sophisticated structural models can solve for that. Our study, on the other side,

focuses more on changes in trends in average prevalence. What makes this study novel is the use of the unique NSDUH data set to account for the potential trends in substance prevalence among individuals who have a tendency towards addiction. However, this can be a potential source of bias in our estimates, since we are tracking individuals who are prone to substance and drug addiction. Another weakness of this study is the lack of fine-grained data/granulated data. In fact, this data set is limited to the state and year level, so that the detailed effects of cannabis legislations cannot be clearly captured. Even state and year fixed effects cannot fully capture the effects of such varying legislations. Therefore, having access to the full data set with state identifiers would produce more reliable and accurate estimations. Despite this the research presented in this paper offers a glimpse into the potential links between cannabis legalization and the use of tobacco and alcohol. Even with limited data its clear there are strong correlations between the use of each substance. This has significant implications for policy makers that are considering legalization.

Overall, although limited by the absence of a more granulated data set, this paper finds a negative and significant relationship between average tobacco prevalence and the legalization of cannabis for either medical or recreational use. It finds no strong positive or negative relationship between alcohol and cannabis. These findings do not parallel exactly the conclusions reached by some similar studies that found no significant association between the legalization of cannabis and sales of cigarettes and alcohol [Veligati et al. (2020)]. While alcohol use seems unaffected by legalization of cannabis the coefficient estimates relating tobacco use to cannabis legalization are large and significant. Given the desire of politicians to limit tobacco use, these results could play a major role in considering future policy decisions around cannabis legalization.

The question of substitutability or complementarity between cannabis and alcohol and tobacco does not have a 'one-size-fits-all' type of answer [Guttmannova et al. (2016)]. In fact, various studies carried out in the past on the subject had contrasting results. One potential explanation for that can be found in the psychology literature, whereby an individual pattern of consumption for drugs depends on preferences and motivations. These preferences vary widely across individuals [Simons et al. (2005)]. Future studies should aim towards obtaining more granulated individual level data and the inclusion of more covariates such as age, gender, and even taxes on alcohol, tobacco and cannabis consumption. The use of more sophisticated structural models can also be used to account for the endogeneity problem between the three substances to shed more light on these notoriously-debated relationships.

REFERENCES

[Akre et al. 2009] Akre, C. ; Michaud, P. ; Berchtold, A. ; Suris, J.: Cannabis and tobacco use: where are the boundaries? A qualitative study on cannabis consumption modes among adolescents. In: *Health Education Research* 25 (2009), Nr. 1, S. 74–82

[Amlung et al. 2019] Amlung, M. ; Reed, D. ; Morris, V. ; Aston, E. ; Metrik, J. ; MacKillop, J.: Price elasticity of illegal versus legal cannabis: a behavioral economic substitutability analysis. In: *Addiction* 114 (2019), Nr. 1, S. 112–118

[Becker et al. 2006] Becker, G. ; Murphy, K. ; Grossman, M.: The Market for Illegal Goods: The Case of Drugs. In: *Journal of Political Economy* 114 (2006), Nr. 1, S. 38–60

[Cameron and Williams 2001] Cameron, L. ; Williams, J.: Cannabis, Alcohol and Cigarettes: Substitutes or Complements? In: *Economic Record* 77 (2001), Nr. 236, S. 19–34

[Caulkins 2012] Caulkins, J.: Design considerations for legalizing cannabis: lessons inspired by analysis of California's Proposition 19. In: *Addiction* 107 (2012), Nr. 5, S. 865–871

[Caulkins and Pacula 2016] Caulkins, J. ; Pacula, R.: Marijuana Markets: Inferences from Reports by the Household Population. In: *Journal of Drug Issues* 36 (2016), Nr. 1, S. 173–200

[Fendrich and Johnson 2005] Fendrich, M. ; Johnson, T: Race/ethnicity differences in the validity of self-reported drug use: results from a household survey. In: *Journal of Urban Health* 82 (2005), Nr. 2, S. 67–81

[Guttmannova et al. 2016] Guttmannova, K. ; Lee, C. ; Kilmer, J. ; Fleming, C. ; Rhew, I. ; Kosterman, R. ; Larimer, M.: Impacts of Changing Marijuana Policies on Alcohol Use in the United States. In: *Alcohol: Clinical and Experimental Research* 40 (2016), Nr. 1, S. 33–46

[Simons et al. 2005] Simons, J. ; Gaher, R. ; Correia, C. ; Hansen, C. ; Christopher, M.: An affective-motivational model of marijuana and alcohol problems among college students. In: *Psychology of Addictive Behaviors* 19 (2005), Nr. 3, S. 326–334

[State Policies Department 2020] State Policies Department, MPP: *Marijuana Policy Progress Report 2019 Legislative Update*. 2020. – URL `https://www.mpp.org/issues/legislation/`

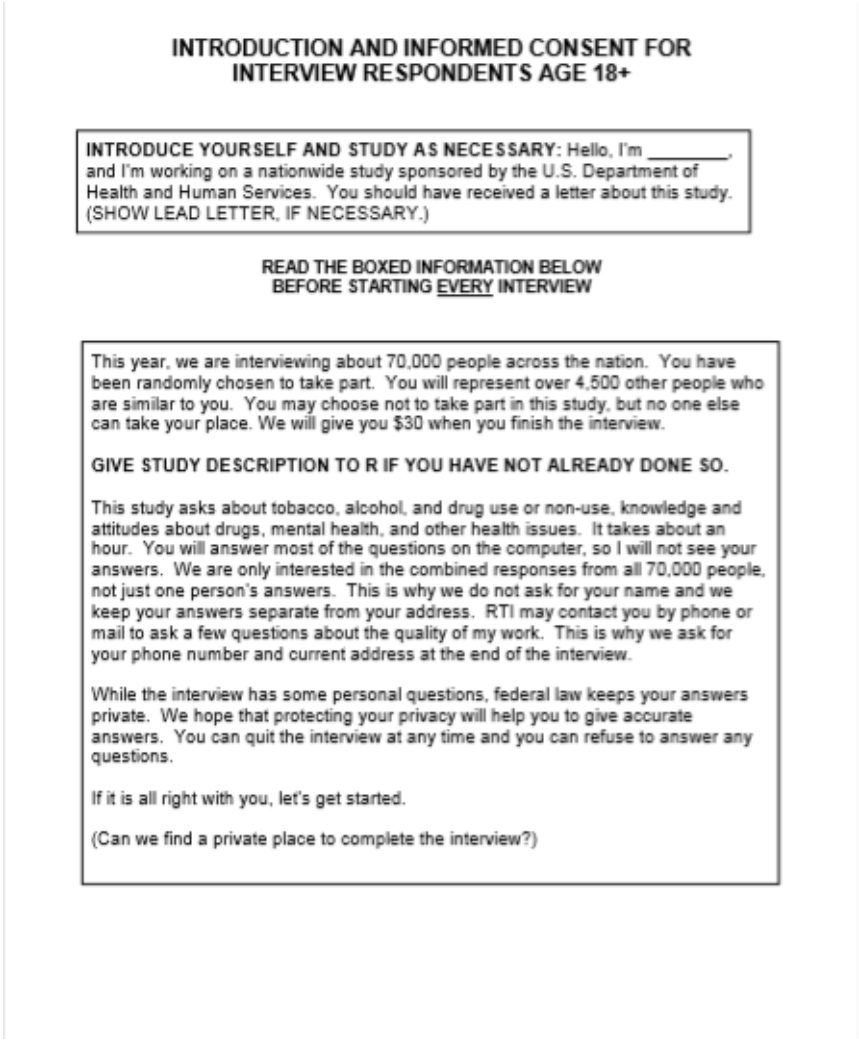
[Veligati et al. 2020] Veligati, S. ; Howdeshell, S. ; Beeler-Stinn, S. ; Lingam, D. ; Allen, P. ; Chen, L. ; Grucza, R: Changes in Alcohol and Cigarette Consumption in Response to Medical and Recreational Cannabis Legalization: Evidence from U.S. State Tax Receipt Data. In: *International Journal of Drug Policy* 102585 (2020)

[Verbic et al. 2001] Verbic, M. ; Cok, M. ; Peric, P.: An economic analysis of the illegal marijuana market in Slovenia. In: *Economic Research* 32 (2001), Nr. 1, S. 657–672

APPENDIX

Order	State	Legalization year	Order	State	Legalization year	Order	State	Legalization year
1	Alabama	N/A	20	Maine	1999	40	Rhode Isla	2006
2	Alaska	2014	21	Maryland	2013	41	South Car	2014
3	Arizona	2010	22	Massachu	2012	42	South Dak	N/A
4	Arkansas	2016	23	Michigan	2008	43	Tennessee	N/A
5	California	1996	24	Minnesota	2014	44	Texas	2015
6	Colorado	2012	25	Mississipp	N/A	45	Utah	2014
7	Connecticu	2012	26	Missouri	2018	46	Vermont	2004
8	Delaware	2011	27	Montana	2004	47	Virginia	N/A
9	District of	1998	28	Nebraska	N/A	48	Washingto	1998
10	Florida	2017	29	Nevada	2000	49	West Virgi	2017
11	Georgia	2015	30	New Hamp	2013	50	Wisconsin	N/A
12	Hawaii	2000	31	New Jerse	2010	51	Wyoming	N/A
13	Idaho	N/A	32	New Mexic	2007			
14	Illinois	2014	33	New York	2014			
15	Indiana	2017	34	North Caro	N/A			
16	Iowa	2014	35	North Dak	2016			
17	Kansas	N/A	36	Ohio	2016			
18	Kentucky	N/A	37	Oklahoma	2018			
19	Louisiana	2015	38	Oregon	1998			
20	Maine	1999	39	Pennsylva	2016			

Figure A1. List of states with legalization dates



INTRODUCTION AND INFORMED CONSENT FOR INTERVIEW RESPONDENTS AGE 18+

INTRODUCE YOURSELF AND STUDY AS NECESSARY: Hello, I'm _____, and I'm working on a nationwide study sponsored by the U.S. Department of Health and Human Services. You should have received a letter about this study. (SHOW LEAD LETTER, IF NECESSARY.)

READ THE BOXED INFORMATION BELOW BEFORE STARTING EVERY INTERVIEW

This year, we are interviewing about 70,000 people across the nation. You have been randomly chosen to take part. You will represent over 4,500 other people who are similar to you. You may choose not to take part in this study, but no one else can take your place. We will give you $30 when you finish the interview.

GIVE STUDY DESCRIPTION TO R IF YOU HAVE NOT ALREADY DONE SO.

This study asks about tobacco, alcohol, and drug use or non-use, knowledge and attitudes about drugs, mental health, and other health issues. It takes about an hour. You will answer most of the questions on the computer, so I will not see your answers. We are only interested in the combined responses from all 70,000 people, not just one person's answers. This is why we do not ask for your name and we keep your answers separate from your address. RTI may contact you by phone or mail to ask a few questions about the quality of my work. This is why we ask for your phone number and current address at the end of the interview.

While the interview has some personal questions, federal law keeps your answers private. We hope that protecting your privacy will help you to give accurate answers. You can quit the interview at any time and you can refuse to answer any questions.

If it is all right with you, let's get started.

(Can we find a private place to complete the interview?)

Figure A2. NSDUH survey front page

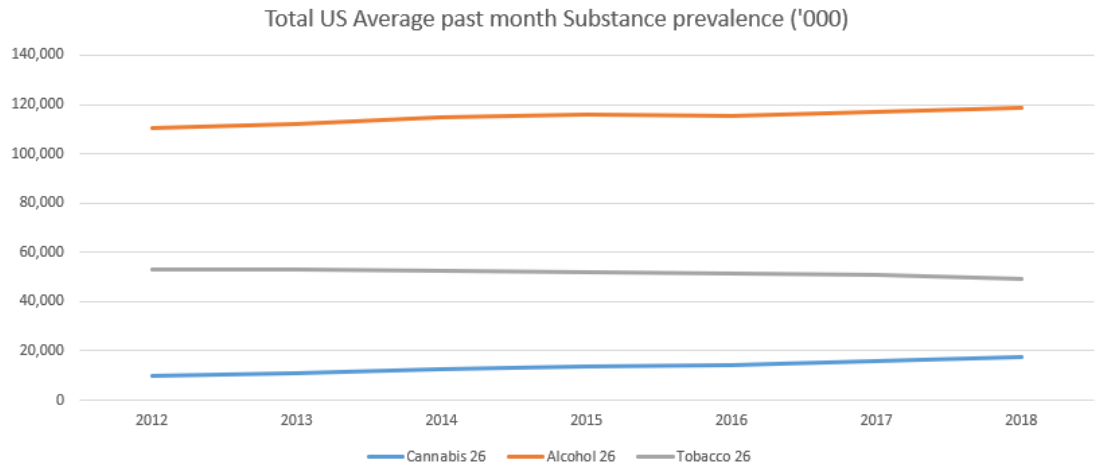


FIGURE A3. TRENDS US TOTAL

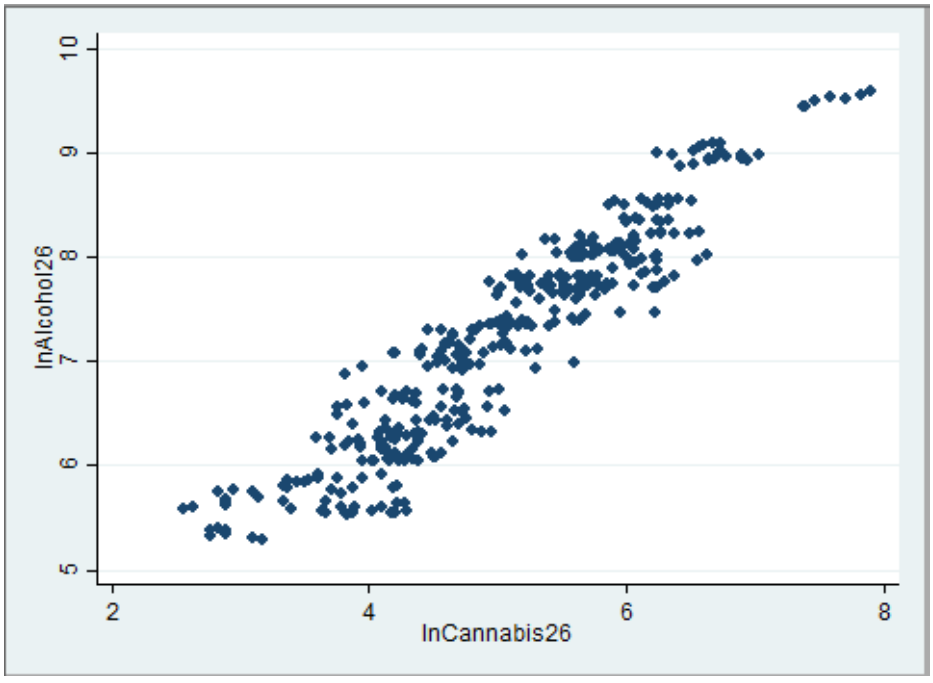


FIGURE A4. CORRELATION LOG TOBACCO AND LOG ALCOHOL