

Analyzing the effect of Legalization on Black-Market Marijuana Prices

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Abstract

This paper aims to analyze the relationship between legalization and the price of marijuana in the black market. It is found that post-legalization, marijuana prices have risen in the black-market contrary to what theory would dictate which is an expected decrease in price due to competition with legal marijuana. The reasons for this conclusion are explained and supported by literature outlining economic, sociological, and psychological factors that may influence consumer behaviour. The current hypothesis from this study's conclusion is a potentially flooded marijuana market due to the hype of legalization. The price inelastic as well as pecuniary and non-pecuniary factors of marijuana consumption play a role in persistent demand for marijuana regardless of the source which may have resulted in a sub-influx of consumers back into the illegal marijuana market. The study and analysis of price should continue for the next couple of months to see if the corrections of supply shortages will result in smaller price differentials, reducing and achieving a primary goal which is the eradication of the black market.

Introduction

With the legalization of recreational cannabis in Canada on October 17, 2018, policy analysts have lent a close eye towards observing whether the intended effects of legalization are coming to fruition. One of the key motivators for legalization was the eradication of the marijuana black market, essentially eliminating the risk of minors being able to purchase marijuana as well as claiming lost tax benefits due to an illegal black market. It has been 5 months since legalization, and while researchers and academics are analyzing the problem from their respective areas of expertise, the black-market problem post-legalization is an area lacking analysis. According to an Ipsos study conducted in November 2019, 35% of cannabis users still make purchases in the black market (Macey, 2019). It is logical to hypothesize that the price of marijuana in the black market relative to the legal market is a huge determinant of whether people will legally purchase marijuana due to both goods being very close substitutes. To build the groundwork for further analysis into the amount of illegally-sold marijuana consumed post-legalization, it is imperative to analyze the relationship between legalization and the price of marijuana sold illegally in the black market.

By analyzing and conducting further research on this topic, the results of this study can prove quite useful to policy decisionmakers. Basic prohibition economic theory would indicate that if an illicit good was legalized and was supplied in regular markets, then the demand for the good in the black market would shift to the left. Eventually, as seen with alcohol during the prohibition-era, the equilibrium price and demand for the good in the black market would move to the origin, essentially eliminating the black market.

While the above hypothesis seems logical and sound, in this paper, we find that the theory is not supported. In fact, after analyzing the Statistics Canada survey with over 19,000 responses

recorded from January 2018 to January 2019, after accounting for all other variables included in the data, there is a strong positive correlation between the legalization of marijuana and prices of illegal marijuana.

Literature Review

While there lacks specific literature on the effects of legalization on the price of illegally purchased black-market marijuana, there is substantial research on factors that may play a role in understanding the relationship studied in this paper. These factors include looking at consumer behaviour, alcohol's response to legalization post-prohibition, as well as the projected size of illegal black markets.

Price elasticity of demand measures how responsive quantity demanded is to a change in price. Davis studies this relationship in the marijuana industry through his study looking at crowd-sourced data from all US states, except Alaska and Hawaii, with the goal to estimate the price elasticity of demand for marijuana. An OLS regression is conducted and leads to a statistically significant estimate of the price elasticity of demand of marijuana being between -0.3 and -0.6. (Davis, 2013, pg. 18). This implies that marijuana is relatively price inelastic and is in line with precedential analysis conducted by Nisbet and Vakil at UCLA in 1972. Small price changes would not have a significant effect on quantity demanded reflecting the nature of marijuana consumption.

The price inelastic nature of marijuana demand can be explained by looking at Gruber's economic analysis of youth risky behaviour. Gruber analyzes CDC survey data gained from a national health survey and finds there to be an increase in illegal youth marijuana consumption almost doubling throughout the 1990s (Gruber, 2000). However, it is important to note that while

youth usage sharply rose during this period, adult-use stagnated. This possibly implies that marijuana lacks the same addictive features found in other drugs and have less potential for abuse, pointing towards youth psychological and sociological factors. Pacula's literature review analyzes legalization's impact on consumption, outlining some of the monetary, psychological and sociological factors that were not delved into in Gruber's economic analysis. Pacula concludes that while a significant and specific study analyzing legalization and consumption is lacking, literature points towards increased consumption post-legalization due to non-pecuniary variables (Pacula, 2010, pg. 18). Pacula looks at the impact of norms, legal risk reduction, and health risk on legalization and points out that psychological and sociological literature suggests increased consumption post-legalization (Pacula, 2010, pg. 17). We must note that this study was built off literature prior to the legalization of marijuana and bases some analysis off alcohol and tobacco. This may tamper analysis since the effects of marijuana differs from alcohol and tobacco with respect to non-pecuniary effects (mainly attitude towards legal risk due to addictive nature of substance) from consumption as acknowledged by Pacula (Pacula, 2010, pg. 7). Nonetheless, this study helps conclude that consumption will ultimately increase post-legalization *ceteris paribus*.

Alcohol prohibition economics provides some background information that is essential to understanding the duration of the effects of legalization on price. In her review paper of Phillip J, Cook's work on alcohol analysis, Markowitz outlines the positive impact on taxation from legalization, as well as the inconclusiveness of alcohol addiction due to legalization (Markowitz, 2008, pg. 2). A key distinction between alcohol and marijuana can be made, as Markowitz outlines in the review that an increase in price can drastically affect consumption implying a relatively price elastic demand of alcohol (Markowitz, 2008, pg. 2). Markowitz outlines that

Cook's work lacks literature on the supply side of alcohol, which in the case of the current study may be a huge determinant in explaining the increased prices of black-market marijuana.

Vitaliano clarifies this in his analysis of alcohol prohibition, outlining that the alcohol industry achieves significant economies of scale (Vitaliano, 2014, pg. 47). It is also found that the price elasticity of demand for alcohol ranges from 0.51 to -0.60 depending on the type of alcohol. This mean is relatively higher than the price elasticity of demand found for marijuana from Davis' study, indicating that Cooke's paper that Markowitz reviewed is in line with Vitaliano's as well as existing literature on the price elasticity of demand of alcohol (Vitaliano, 2014, pg. 25).

Marijuana's price elasticity of demand calculated should be looked at with caution however noting that the data used for Vitaliano's study is based on legal alcohol, whereas the marijuana PED study is based on surveyed data in the black market. Overall, Vitaliano concludes that the prohibition-repeal was effective netting an annual benefit of \$432 million after factoring in consumer and producer surplus, crime, health effects and accidents associated with legalization (Vitaliano, 2014, pg. 52). The key part of this study however indicates that there is an underlying difference between supply of alcohol and marijuana post-legalization. This is an indication that although the alcohol case is close to marijuana and some of the results of the study are useful for analyzing legalization's impact on marijuana, it is far from an ideal substance to be used as a comparison.

The goal of analyzing the relationship between the price of illegal black-market marijuana and legalization is to see whether policymakers are on route to achieving their goal of black-market eradication. Sen and Wyonch estimate the short-term (October 2018 to September 2019) size of the illegal marijuana market to be at least \$2.5 billion (Sen, Wyonch, 2018, pg. 15). This translates into a huge tax loss and is attributed to supply shortages in the legal market as well as

differentiating black market and legal market marijuana prices. From calculations in the October 2018 released paper, the average price of illegal marijuana is \$5.86 to \$9.51. This range is relatively smaller than the price of legal marijuana which ranged from \$8.37 to \$9.52 (Sen, Wyonch, 2018, pg. 13). The price differentials can partly be attributed to supply shortages. Furthermore, it is mentioned that the supply shortages will most probably decrease over time (Sen, Wyonch, 2018, pg. 3). This potentially allows the legal market to compete on price and eventually drive out demand for black-market marijuana but would need to be confirmed through further continuations of both the estimation of the black-market size study as well as the current legalization's impact on price study over the next few years.

Data

The data used for analysis surveys Canadians through a crowdsourcing site. Responses recorded include the date of submission, quantity purchased, price paid per gram, the purpose for usage, and the location of purchase. While this data set is not riddled with missing data for these variables, one key variable significant to this study that should have been recorded is not presented. That is the source of the marijuana. It is unclear whether the observations analyzed were purchased from a legally-licensed producer/retailer or purchased illegally in the black market through dealers. The survey does record and asks users for their purchase source; however, this data was not released. Thus, for the sake of analysis, we will assume that there is an equal mix of illegal and legal marijuana purchased. For future studies and papers, this variable should be analyzed, and the study should be reconducted with similar analytic techniques presented in this paper.

Results

Table 1

Median	Q=1g	1<Q<=5g	5<Q<10g	10g<Q
Pre-legalization Price (\$)	8.50	8.57	7.14	5.71
Post-legalization Price (\$)	10.00	9.51	9.51	5.36

Mean	Q=1g	1<Q<=5g	5<Q<10g	10g<Q
Pre-legalization (\$)	8.33	8.51	7.69	5.89
Post-legalization (\$)	9.02	9.71	8.42	5.81

```
lm(formula = marijuana$Price ~ legalization + marijuana$Quantity +
    usage + location)
```

By analyzing the median and mean prices by quantities purchased in Table 1, we can see an overall increase in price post-legalization. This is a very loose summary of the results indicating that it is possible that legalization had an impact on increased marijuana prices in the black market. To draw a clear picture of the importance of legalization on the price of marijuana, it was decided to conduct a linear regression.

Table 2

Intercept	Estimate	P-value
legalization	0.92	< 2e-16
marijuana quantity	-0.02	< 2e-16
usage	-0.15	1.98E-06
location	0.81	< 2e-16

After analyzing the dummy variable representing legalization, with a P-value much less than 0.05, legalization can be deduced as being a significant variate. The beta estimate is calculated to be 0.92, meaning that legalization correlates to around a dollar increase in the price of marijuana. Due to the missing source value however, it is difficult to conclude whether or not there is a strong correlation between black-market marijuana price and legalization because as mentioned

before, the proportion of legal to illegal marijuana sources are not shown in the imported data set. However, due to the nature of the study as well as the IPSOS study stating that 35% of marijuana is still purchased in the black market, it is fair to assume such a similar proportionately for the sake of this study and estimate that there is indeed a correlation between legalization and the price of marijuana in the black market. Furthermore, we can work with this assumption by comparing the recorded average prices to the prices listed on legal online dispensary sites. The prices for a gram of weed on the Ontario Cannabis Store range between 9-11\$ per gram. With the mean price around \$9 for 1 gram, we can predict assuming a normally distributed price curve that a large portion of at least this sub-sectioned quantity consists of illegally purchased marijuana.

Method

To successfully analyze the effect of legalization on black market prices, it would be best to analyze prices of marijuana that individuals paid on the street before and after legalization. Thus, it was decided to use survey data gathered by Statistics Canada. This data presents prices individuals reported paying as well as other details describing potential variables that can influence marijuana prices such as location, the gender of the buyer, date of purchase and quantity purchased. There are more than 19,000 observations and due to the limited nature of the data observations, certain techniques were taken to get a substantive picture of legalization's effect.

At first, the data was sub-sectioned based on quantity purchased since it is known that buying in bulk reduces per gram price. However, due to a lack of data, it was found to be necessary to divide the data in ranges of quantity. In other words, 1 gram was looked at individually while 3.5 grams was included in a range from 1 to 5 grams purchased. The next level included 5 to 10

grams purchased, and the final level included data of purchases greater than 10 grams. Of the variables observed in the Stats Canada data, my goal was to observe whether legalization had an impact. Thus, I was specifically interested in the submission date which was interpreted as being purchased before or after legalization.

Conclusion/Next Steps

Overall from this study, we can see a positive correlation between marijuana prices and legalization. Whether this translates into higher black-market marijuana prices or legally purchased marijuana prices is definable based on the assumption that a significant portion of the data set measures illegally purchased marijuana. There are two competing hypotheses that should be looked at. The first is the possibility that people value acting within the bounds of the law and thus will overlook slight price differences to purchase and consume marijuana legally. The second hypothesis is that the price of substitute goods is a significant indicator of consumption, and thus due to relatively higher prices in the legal market (being a new market and relatively inefficient at the moment), consumers are flooding back to their dealers who are able to supply marijuana at a lower price. Currently, the second hypothesis is prevalent. From Sen and Wyonch's study of the size of the illegal market, supply shortages and price-differentials play a huge part in this problem. Specifically, due to there being supply shortages, legal marijuana is relatively priced higher than illegal marijuana. This alone would not be sufficient to explain increased prices in the illegal market post-legalization. A possible explanation can be that there was an influx of consumer demand for marijuana due to hype around legalization, but due to supply shortages and price differentials, these existing and new consumers flooded the illegal marijuana market. As outlined by Davis, Pacula and Gruber in their respective works,

demand for marijuana is price inelastic in nature and consumption tends to persist despite legal consequences.

This study can establish the correlation between overall marijuana prices and legalization, but to improve on this analysis, data should continuously be collected as it is possible the increased prices are attributable to an inefficient legal marijuana market. Furthermore, if possible, the source should be recorded so there is no need to make assumptions regarding how cannabis was purchased.

Reference List

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Gruber, Jonathan. "Risky Behavior Among Youths: An Economic Analysis." *National Bureau of Economic Research*, 2000. doi:10.3386/w7781.

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Appendix

R-Code

```
> ## The data will be analyzed by Quantity, Location, Usage
> library(ggplot2)
> library(dplyr)
> library(plyr)
> library(lubridate)
>
> ##Exploratory Analysis
> marijuana=read.csv("cannabis file for 472.csv", header = TRUE, stringsAsFac
tors = FALSE)
> attach(marijuana)
```

The following objects are masked from marijuana (pos = 3):

```
Census.division,
Census.metropolitan.area,
Census.subdivision, Consumption,
Economic.region, Expenditure,
First.time, Legal.status, Outlier,
Price, Province, Purpose,
Quantity, Sex.at.birth, Source,
Submission.Date, Usage
```

```
> head(marijuana, n=10)
```

	Submission.Date	Expenditure	Quantity
1	2018-01-25	5.00	1
2	2018-01-25	10.00	1
3	2018-01-25	8.00	1
4	2018-01-25	13.00	1
5	2018-01-25	10.00	1
6	2018-01-25	10.00	1
7	2018-01-25	5.00	1
8	2018-01-25	3.22	1
9	2018-01-25	10.00	1
10	2018-01-25	5.00	1

	Price	Outlier
1	5.00	0
2	10.00	0
3	8.00	0
4	13.00	0
5	10.00	0
6	10.00	0
7	5.00	0
8	3.22	0
9	10.00	0
10	5.00	0

	Purpose
1	Use recreationally
2	Use recreationally
3	Use recreationally
4	Use recreationally
5	Use recreationally
6	Medicate - without a medical document
7	Use recreationally
8	Use recreationally

9 Use recreationally
 10 Use recreationally
 Usage Source

1
 2
 3 A few times a year
 4 A few times a year
 5
 6
 7 Daily
 8 A few times per month
 9 A few times a year
 10 Daily
 Sex.at.birth First.time Legal.status

1
 2
 3
 4
 5
 6
 7
 8
 9
 10

Consumption Census.subdivision
 1 NA Gatineau
 2 NA Gatineau
 3 0.50 Longueuil
 4 0.05 Montréal
 5 NA Laval
 6 NA Lac-Saguay
 7 60.00 Montréal-Est
 8 1.00 Longueuil
 9 0.50 Saguenay
 10 28.00 Trois-Rivières

Census.division
 1 Gatineau
 2 Gatineau
 3 Longueuil
 4 Montréal
 5 Laval
 6 Antoine-Labelle
 7 Montréal
 8 Longueuil
 9 Le Saguenay-et-son-Fjord
 10 Francheville

Economic.region Province
 1 Outaouais Quebec / Québec
 2 Outaouais Quebec / Québec
 3 Montérégie Quebec / Québec
 4 Montréal Quebec / Québec
 5 Laval Quebec / Québec
 6 Laurentides Quebec / Québec
 7 Montréal Quebec / Québec
 8 Montérégie Quebec / Québec
 9 Saguenay--Lac-Saint-Jean Quebec / Québec
 10 Mauricie Quebec / Québec

```

                                Census.metropolitan.area
1  Ottawa - Gatineau (partie du Québec / Quebec part)
2  Ottawa - Gatineau (partie du Québec / Quebec part)
3                                Montréal
4                                Montréal
5                                Montréal
6                                24 - NonCMA
7                                Montréal
8                                Montréal
9                                Saguenay
10                               Trois-Rivières
>
> marijuana$Submission.Date <- as.Date(marijuana$Submission.Date)
>
>
> ##Overall data before and after prices including
> prior <- filter(marijuana, marijuana$Submission.Date<"2018-10-17" & marijuana$Submission.Date>="2018-07-01")
> post <- filter(marijuana, marijuana$Submission.Date>="2018-10-17")
>
> median(prior$Price)
[1] 7.14
> mean(prior$Price)
[1] 7.139643
>
> median(post$Price)
[1] 7.435
> mean(post$Price)
[1] 7.886689
>
>
> ## Analyzing Data By Quantities 1, 3.5, 7, 14, and 28 since there are relatively large number of
> ## observations for these values
> q1 <- filter(marijuana, marijuana$Quantity==1)
> q1to5 <- filter(marijuana, marijuana$Quantity>1 & marijuana$Quantity<=5)
> q5to10 <- filter(marijuana, marijuana$Quantity>5 & marijuana$Quantity<=10)
> q10plus<- filter(marijuana, marijuana$Quantity>10)
>
> #Overall Median and Mean Calculations
> median(q1$Price)
[1] 8.5
> median(q1to5$Price)
[1] 7.14
> median(q5to10$Price)
[1] 7.14
> median(q10plus$Price)
[1] 5.71
>
> mean(q1$Price)
[1] 8.19399
> mean(q1to5$Price)
[1] 7.728872
> mean(q5to10$Price)
[1] 7.347063
> mean(q10plus$Price)
[1] 5.756916

```

```

>
> ## Period 1 = p1 => 2018-01-01 to 2018-03-30
> ## Period 2 = p2 => 2018-04-01 to 2018-06-30
> ## Period 3 - p3 => 2018-07-01 to 2018-10-16
> ## Period 4 = p4 => 2018-10-17 to 2019-01-31
>
> ## Q1 Median and Mean Prices over Periods Pi i=3 and i=4 representing 4 months prior and post-legalization
> q1p3 <- filter(q1, q1$Submission.Date>="2018-07-01" & q1$Submission.Date<"2018-10-17")
> q1p4 <- filter(q1, q1$Submission.Date>="2018-10-17" & q1$Submission.Date<"2019-04-01")
>
> median(q1p3$Price, na.rm = TRUE)
[1] 8.5
> median(q1p4$Price, na.rm = TRUE)
[1] 10
>
> mean(q1p3$Price, na.rm = TRUE)
[1] 8.32622
> mean(q1p4$Price, na.rm = TRUE)
[1] 9.022597
>
> ## Ontario
> q1p3on <- filter(q1p3, q1p3$Province=="Ontario")
> q1p4on <- filter(q1p4, q1p4$Province=="Ontario")
> median(q1p3on$Price)
[1] 9
> median(q1p4on$Price)
[1] 10
> mean(q1p3on$Price)
[1] 8.550377
> median(q1p4on$Price)
[1] 10
>
> ## Non-ontario
> q1p3noton <- filter(q1p3, q1p3$Province!="Ontario")
> q1p4noton <- filter(q1p4, q1p4$Province!="Ontario")
> median(q1p3noton$Price)
[1] 8
> median(q1p4noton$Price)
[1] 8
> mean(q1p3noton$Price)
[1] 8.078194
> median(q1p4noton$Price)
[1] 8
>
> ## Q1to5 Median and Mean Prices over Periods Pi i=3 and i=4 representing 4 months prior and post-legalization
> q1to5p3 <- filter(q1to5, q1to5$Submission.Date>="2018-07-01" & q1to5$Submission.Date<"2018-10-17")
> q1to5p4 <- filter(q1to5, q1to5$Submission.Date>="2018-10-17" & q1to5$Submission.Date<"2019-04-01")
> median(q1to5p3$Price, na.rm = TRUE)
[1] 8.57
> median(q1to5p4$Price, na.rm = TRUE)
[1] 9.51

```



```

>
> mean(q1to5p3$Price, na.rm = TRUE)
[1] 8.512229
> mean(q1to5p4$Price, na.rm = TRUE)
[1] 9.705164
>
> ## Q5to10 Median and Mean Prices over Periods Pi i= 3 and i=4
> q5to10p3 <- filter(q5to10, q5to10$Submission.Date>="2018-07-01" & q5to10$Submission.Date<"2018-10-17")
> q5to10p4 <- filter(q5to10, q5to10$Submission.Date>="2018-10-17" & q5to10$Submission.Date<"2019-04-01")
>
> median(q5to10p3$Price, na.rm = TRUE)
[1] 7.14
> median(q1to5p4$Price, na.rm = TRUE)
[1] 9.51
>
> mean(q5to10p3$Price, na.rm = TRUE)
[1] 7.688333
> mean(q5to10p4$Price, na.rm = TRUE)
[1] 8.418519
>
> ## Q10plus Median and Mean Prices over Periods Pi i=3 and i=4
> q10plusp3 <- filter(q10plus, q10plus$Submission.Date>="2018-07-01" & q10plus$Submission.Date<"2018-10-17")
> q10plusp4 <- filter(q10plus, q10plus$Submission.Date>="2018-10-17" & q10plus$Submission.Date<"2019-04-01")
>
> median(q10plusp3$Price, na.rm = TRUE)
[1] 5.71
> median(q10plusp4$Price, na.rm = TRUE)
[1] 5.36
>
> mean(q10plusp3$Price, na.rm = TRUE)
[1] 5.886308
> mean(q10plusp4$Price, na.rm = TRUE)
[1] 5.813765
>
> ##Regression looking at legalization and Price
> legalization <- as.numeric(marijuana$Submission.Date>="2018-10-17")
> usage <- as.numeric(marijuana$Purpose=="Use recreationally")
> location <- as.numeric(marijuana$Province == "Ontario")
> marijuana.lm <- lm(marijuana$Price~legalization+marijuana$Quantity+usage+location)
> summary(marijuana.lm)

```

Call:

```
lm(formula = marijuana$Price ~ legalization + marijuana$Quantity +
    usage + location)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-5.7900	-1.4526	-0.2825	1.2100	25.8913

Coefficients:

	Estimate	Std. Error
(Intercept)	6.9986264	0.0283715

legalization	0.9209051	0.1024329
marijuana\$Quantity	-0.0194998	0.0004885
usage	-0.1496080	0.0314532
location	0.8109177	0.0333213

	t value	Pr(> t)
(Intercept)	246.678	< 2e-16 ***
legalization	8.990	< 2e-16 ***
marijuana\$Quantity	-39.921	< 2e-16 ***
usage	-4.757	1.98e-06 ***
location	24.336	< 2e-16 ***

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.'

0.1 ' ' 1

Residual standard error: 2.146 on 19872 degrees of freedom
 Multiple R-squared: 0.105, Adjusted R-squared: 0.1049
 F-statistic: 583.1 on 4 and 19872 DF, p-value: < 2.2e-16