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An Empirical Exploration of the Effects of Medical Marijuana Laws

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Abstract:

This exploration into the multiple effects of medical marijuana laws on regional marketplaces uses a novel data set and contributes three unique and important findings. First, in states with medical marijuana legislation the price of marijuana is significantly lower than states without similar legislation, this is likely due to measures that allow for legalized avenues of production and distribution. Secondly, because of price breaks for bulk purchases, retail level distributers operate on a downward sloping supply curve that is less steep in medical marijuana states; this is likely due to decreased risk of distribution which may reduce preference for lower margin, higher volume transactions. Finally, in states with medical marijuana laws, variance in purchase price is substantially less, presumably due to the decreased cost of information seeking and decreased risk of advertisement.

Introduction:

As conventional policies aimed at curbing marijuana consumption continue to fall short, new information is necessary to motivate better, more effective drug policy. There is no comprehensive body of literature about the institutions and functions of the marijuana marketplace, nor has there been an in-depth analysis of the market effects of medical marijuana legislation, an important step in understanding the most commonly used illicit drug in the United States. (The Substance Abuse and Mental Health Services Administration, 2009) While this paper does not attempt to provide a comprehensive understanding of marijuana markets, it begins to fill the void in research surrounding the effects of medical marijuana laws on markets by surveying the myriad effects of legislation on transactions.

Recently a new body of data has become available which allows for an in depth look into the retail level market for marijuana. Not only is the data rich with important information on price, quality and location, but it also overcomes some of the non-random sampling and reliability issues of other data sets that have limited the power of previous research. This data along with important contributions from other authors makes possible, a more accurate, yet preliminary look into the effects of medical marijuana laws that alter the structure and institutions of existing marketplaces.

Literature Review:

A great deal of research has been done into marijuana markets, the determinants of their prices and apparent geographic discrepancy in pricing. Studies have explored the supply-side effects of various drug policies and their impact on perceived danger of distribution using the theory of the rational criminal as the basis for their analysis. (Reuter & Kleiman, 1986) Many papers have implied a geographic difference in the price of marijuana and many contemporary

studies concerning the markets for marijuana validate the assumption that the demand curve for marijuana is downward sloping and that marijuana is a normal good (Clements, 2004, Caulkins & Pacula, 2006)

A central concern in much of the research of illicit marketplaces is the quality and availability of data, particularly in the case of drug marketplaces where transaction level data is powerful, yet hard to come by. Clements uses collected prices of marijuana over a span of 9 years through undercover police purchases of unknown quantities and qualities, data collection methods that, while useful, at the very least present issues of non-random sampling and omitted variable bias. (Clements, 2004) Other models and papers have used both the Arrestee Drug Abuse Monitoring Program which only observe arrestees reported price per unit. Similarly, the National Survey on Drug Use and Health, observations were over-sampled to obtain better estimates for Black and Hispanic users and do not account for geographical differences. (Caulkins & Pacula)

Clements (2004) estimates demand in Australian markets using data acquired from undercover police purchases. He tests for effects in the varying degrees of legality on consumption and finds evidence for individual, regional marketplaces, decreasing prices over time and a downward sloping demand curve. Additionally, Clements finds evidence of discounted pricing with increasing quantities, possibly because of risk associated with every transaction or other types of transactions costs.

Clements and Zhao, in their detailed book *Economics and Marijuana* (2010) have found that recently marijuana has undergone a "hydroponic revolution." Because marijuana can be grown indoors it is no longer necessary that it only grown solely in areas conducive to outdoor cultivation. This gives additional strength to the theory that regional market places are possible and probable and has interesting implications on where marijuana can be grown as it no longer

requires an ideal natural climate. Clements and Zhao have also proposed that marijuana packaging, particularly as it relates to bulk discounts, is similar to other legal goods in that higher volume transactions are preferred when transactions costs are a significant factor. Additionally, they provide arguments explaining that some of the disparity in price paid between two otherwise identical buyers is likely to information asymmetry and may not reflect any substantive difference in product.

Caulkins & Pacula (2006) analyze The Substance Abuse And Mental Health Services Administration's National Household Survey on Drug Abuse and give insight into the structure of the retail market. They find that over half of marijuana users have received marijuana for free in 2001, however they make no distinction between smoking marijuana with others for free versus receiving it in loose form. Most importantly, they distinguish marijuana transactions from those that take place in open-air markets, as is typical for a heroin, cocaine, crack-cocaine or methamphetamine transactions. Instead, they provide empirical evidence to suggest that the majority of marijuana transactions take place in users' or dealers' homes or semi-private spaces. This paints a picture of marijuana markets rooted in social circles rather than a more typical, impersonal black market. Because marijuana transactions are typically between friends and acquaintances rather than in open-air markets, information asymmetries could lead to larger discrepancies in price between two otherwise equal buyers. This type of marketplace suggest that retail level distributers may not take into account risk associated with distribution the same way as distributers might, as the risks of getting caught are presumably lower due to a different market structure and controlled clientele.

Finally, much of the literature surrounding the topic suggests that marijuana markets are largely understudied. Pacula et al (2007) makes this explicitly clear when acknowledging that virtually no work has been done on estimating a supply curve for marijuana. Pacula et al have

argued that the supply curve is upward sloping, however the reasoning employed to reach that conclusion had little empirical support.

General Theory:

Most illegal drugs' rates of usage vary across geography.[1] (Substance Abuse And Mental Health Services Administration, 2007) Although both marijuana and agricultural products show geographical price and consumption differences, they are likely not caused by the same thing. One of the many explanations for the regional variances in marijuana usage is cultural and social norms, acceptability and regional habit (tastes and preferences). One would expect that equilibrium price will affect willingness to purchase marijuana based on social and legal consequences. Using this reasoning, variables that approximate these norms or rates of usage may represent demand shifters. Supply may also be affected by similar variables if one were to assume that social acceptability and risk of being prosecuted were correlated. Unfortunately, there is no reliable data available directly relating to the social acceptability of marijuana or exact quantity consumed on a per state basis. There are, however, other estimates that can serve some of the same functions like medical marijuana laws and less accurate estimates of the number of marijuana users per state.

The effect of medical marijuana laws is particularly nuanced because of its implications on both supply and demand. Medical marijuana laws are proposed by those who believe marijuana to beneficial and passed by a majority who agree; in this light, beliefs about the drug can be understood as indicators of social acceptability. Assuming this is true and that social acceptability is a possible demand shifter, we may expect medical marijuana laws to represent a relative increase in demand and therefore price. Another possible effect of medical marijuana

[1] SAMHSA's data corroborates the widely understood notion that certain drugs are more prevalent in certain areas. For instance, heroin is much more widely used in urban areas.

laws on demand is that medical laws make marijuana commercially available to patients of even the most minor conditions, if we assume that these users would not otherwise be purchasing marijuana, we would expect to see increases in demand. Interpreting the effect of medical marijuana laws on price is complicated by the assumption that the laws almost certainly have an effect on supply. One of many possible effects of medical marijuana laws on supply is that certain channels of distribution become legalized. As the number of growers and distributers increases we would expect an increase in supply that would have a downward effect on price.

Interestingly, the legitimization of certain means of cultivation and distribution may lead to more perfect information between buyers and sellers. For instance, in many local newspapers there are advertisements for different qualities, quantities and prices of marijuana readily available to the consumer that may have the effect of stabilizing marijuana prices in a given market. If retailers can advertise prices, it may induce competition among legitimate and illegitimate distributers under the assumption that medical and non-medical marijuana are competing goods. If this is true, we would expect to see variance negatively correlated with Medical Marijuana Laws in tests for heteroscedasticity, a topic which will be explored later in the paper.

Data:

Data primarily comes from priceofweed.com, a crowd sourced, anonymously submitted index that contains information on quantity purchased, amount paid, quality[2] and location. One of the main advantages to this database is that it is a large data set. After cleaning data for observations that likely represent non-armslength transactions (less than $2 per gram) there are still more than 23,000 complete observations. While the database is not entirely a random sample as certain groups of users[3] will be more likely to report, visitors have no incentive to submit faulty information. Aside from access issues, the website is open to all, limiting issues of non-random sampling. An important limitation to note in this data is that reported quantity is truncated at one ounce; this limitation has implications when attempting to estimate a complete supply curve.

Along with the information regarding quantity quality and price, other demographic and descriptive data have been added to observations based on location to control for other factors. Data on drug use per state is gathered from The Arrestee Drug Abuse Monitoring Program and The Substance Abuse and Mental Health Services Administration. Data on statewide median income, population density and education is gathered from the US Census Bureau. We have collected data on the legal status of marijuana from norml.org**.**

We believe that because marijuana is a normal good so median income (in thousands) will have a positive effect on both quantity and price as it is likely a demand shifter. Population density (measured in hundreds of people per square mile) also is likely another demand shifter in that, given a normal distribution of marijuana users, it approximates number of consumers[4].

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[2] A subjective rating of high, medium or low quality

[3] Reporting on the website requires that you have Internet access and the interest to visit the site and share purchase data.

[4] We recognize that population density on the state level is imperfect and might be better suited in a county specific as population is not uniformly distributed throughout the state, however we still believe it to be useful, particularly in regions with smaller state size like New England.

Lastly, we've added a the percentage of individuals in a given state who have consumed marijuana in the past month, we believe this to be an indicator of cultural norms surrounding marijuana and an indicator of the structure and robustness of the market considering it is, in part, a socially distributed drug.

Table 1:

	Mean Quantity (grams)	Mean PPG	Median Population Density	Mean Median Income ($1000)	Mean Marijuana Use	% MMJ laws	n
Division 1	13.14	$13.02	6.46	$60.84	24.24%	67%	1873
Division 2	13.34	$13.19	5.04	$55.40	17.62%	33%	3503
Division 3	13.17	$11.60	2.08	$48.34	16.89%	20%	3559
Division 4	13.09	$12.24	0.58	$49.03	15.17%	0%	1724
Division 5	13.77	$11.81	5.6	$49.89	16.53%	33%	4167
Division 6	14.72	$10.74	1.18	$40.41	14.96%	0%	830
Division 7	14.6	$12.30	0.89	$45.93	11.97%	0%	1686
Division 8	14.06	$11.04	0.36	$50.63	17.88%	63%	1593
Division 9	14.15	$10.69	1.82	$57.25	17.58%	100%	4064
U.S.	13.69	$11.87	3.13	$51.98	17.15%	40%	23023

Table 2:

	n	Percentage
Observations	23023	-
High Quality	14066	61%
Medium Quality	7514	33%
Low Quality	1443	6%
Medical Marijuana State Observations	8337	36%

Regions:

Because demographic data is captured at the statewide level, we have grouped states into regions to avoid perfect colinearity with demographic data. We believe this to be a reasonable solution considering that regional market places likely span across state lines. Regional dummys are comprised of more than one state and grouped with other similar contiguous states according to the US Census groupings.

Divisions: asterisks indicate medical marijuana laws

Division 1 – New England: Connecticut*, Maine*, Massachusetts, New Hampshire, Rhode Island* and Vermont*
Division 2 – Middle Atlantic: New Jersey*, New York and Pennsylvania
Division 3 – East North Central: Indiana, Illinois, Michigan*, Ohio and Wisconsin
Division 4 – West North Central: Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota
Division 5 – South Atlantic: Delaware*, DC*, Florida, Georgia, Maryland*, North Carolina, South Carolina, Virginia and West Virginia
Division 6 – East South Central: Alabama Kentucky, Mississippi and Tennessee
Division 7- West South Central: Arkansas, Louisiana, Oklahoma and Texas
Division 8 - Mountain: Arizona*, Colorado*, Idaho, New Mexico*, Montana*, Utah, Nevada* and Wyoming
Division 9 - Pacific: Alaska*, California*, Hawaii*, Oregon* and Washington*
Medical Marijuana States: Washington, Vermont, Rhode Island, Oregon, New Mexico, New Jersey, Nevada, Montana, Michigan, Maryland, Maine, Nevada, Hawaii, The District of Columbia, Delaware, Connecticut, Colorado, California, Alaska and Arizona

Initial Regression:

$$\begin{aligned}\text{Price} &= \beta_0 + \Sigma\,\text{divisions} + \beta_{11}\text{MedianIncome} + \beta_{12}\text{MarijuanaUse} + \beta_{13}\text{PrcBachelorsDegree} \\ &+ \beta_{14}\text{HighQuality} + \beta_{15}\text{LowQuality} + \beta_{16}\text{MedicalMarijuana} + \beta_{17}\text{PopulationDensity} \\ &+ \beta_{18}\text{PopulationDensitySquared}\end{aligned}$$

Table 3 - Results:

Price Per OZ	Coefficient	Std Error	T	P
			R^2=.24	n=23023
Population Density	-2.953986	0.7983596	-3.7	0
Population Density Squared	0.0402457	0.0079159	5.08	0
Median Income (100)	4.096214	0.249347	16.43	0
Marijuana use 18-25	-1.269789	0.4625847	-2.74	0.01
Bachelors Degree %	-1.278114	0.2803891	-4.56	0
High Quality	125.2319	2.025976	61.81	0
Low Quality	-100.7192	4.073455	-24.73	0
Medical Marijuana Laws	-24.31816	3.494288	-6.96	0
Division 1	79.26636	6.885485	11.51	0
Division 2	81.71779	5.25806	15.54	0
Division 3	54.51247	4.446999	12.26	0
Division 4	57.81926	5.089843	11.36	0
Division 5	52.63758	4.633712	11.36	0
Division 6	53.7629	6.789829	7.92	0
Division 7	63.19737	5.525882	11.44	0
Division 8	16.09983	4.426812	3.64	0
Constant	72.88119	12.6692	5.75	0

All regional effects are statistically significant. The omitted division which all other divisions are measured relative to is division 9. Division 9 has the lowest prices out of all other regions as all other divisions have positive coefficients. Coefficients on quality are intuitive and indicate that high-grade marijuana is more expensive per ounce than medium-grade marijuana and low-grade marijuana sells for $100 less on average than mid-grade.

The population density quadratic indicates there may be a population density that allows for the lowest prices. At very low population densities, there may be significant transaction and transportation costs that contribute to increased prices. Additionally, the social structure of marijuana distribution implies that as population increases, social networks may form allowing easier purchase and lower costs. It may be the case that relatively high population densities are in urban areas where drug enforcement is a higher priority, raising the associated risk and therefore

price. More likely is that if marijuana smokers are somewhat randomly distributed, higher densities mean more demand, and thus higher prices.[5] If we accept the explanations for the U-shaped quadratic, it follows that there is a population density where law enforcement is not a significant issue nor is the effect of price bidding, yet where there is enough demand to sustain a marijuana production and consumption to be the point where, all else equal, prices are lowest.

The coefficient on median income supports the assumption that marijuana is a normal good. Holding all else constant, for every thousand dollars median increases, the model predicts a ~$4 increase in price per ounce. Median income as a demand shifter plays in important role later when estimating a supply curve that necessitates the use of an instrument associated with demand.

Structure of Medical Marijuana Markets:

In most states with medical marijuana laws, production and distribution are not regulated to the extent that most other consumer commodities are. There are no solid figures to estimate production, distribution and retail sales because there are no independent institutions designed to do so. Medical marijuana is in most states a relatively new concept, and because of the discrepancy between state and federal law, medical markets maintain questionable legal status.

Some states have legislated a distribution system that allows small businesses to purchase marijuana from growers and sell to patients who have been referred by doctors. These systems allow some monitoring of the market in that they provide licenses to dispensaries and monitor doctor referrals, however they do not monitor where marijuana is coming from or how much is being grown. (Regan, 2011) Other states like Rhode Island have until recently determined that

[5] It is worth noting that the model only takes into account statewide population density, and that most of the higher density states are located on the east coast where prices may be higher for other reasons as well.

they would provide medical marijuana cards to patients but leave it to patients to acquire it by any means necessary, generally through established drug dealers. (Rhode Island Department of Health, 2006) So, although these states are all considered to have medical marijuana laws, the institutions governing them can be quite different from state to state.

In most states with dispensary style distribution, there are no requirements regarding the business structure of the dispensaries and few guidelines for growers. Because of the lax nature of the laws, many sellers operate for-profit enterprises that in some areas can be intensely competitive, take for example the 750 registered dispensaries in Los Angeles alone or the 187 advertising in Washington state on the registry legalmarijuanadispensary.com, a website with an index of individual dispensaries products and prices. (Kelsey, 2012)

The competitive nature of some states' marketplaces have incited a variety of sellers to enter the market, however because of the questionable legal standing of the industry, the types of entrepreneurs in the industry vary. Although the Department of Justice has made it clear that they will not prosecute any enterprise expressly following state laws, they have on more than one occasion seized the property of and prosecuted persons flaunting their wealth and excessive scale of operations. (DEA, 2011) Take for instance Chris Bartkowicz of Colorado who after appearing in a local news spot about the emerging marijuana economy found himself the subject of a federal investigation and lawsuit. Similarly, take Luke Scarmazzo, a successful medical marijuana businessman only to be taken down after releasing a rap video in which he refers to the DEA unfavorably. (Huffington Post, 2011) Considering the competitive nature of the industry and the very real incentives to keep a low profile and profit reasonable, it is perfectly clear why prices are in part lower in states with medical marijuana dispensaries. In these states, owners have little ability to set prices and even if they did, they would have every incentive to limit either scale of operations or price.

Determinants of Medical Marijuana Laws:

Considering that medical marijuana laws are usually passed by voters, a look into the demographic factors that determine the existence of medical laws might be revealing. Using the data already collected, a simple regression in the following form helps to understand the basics of what makes medical marijuana laws more likely in a state.

$$Medical\ Laws = \beta_0 BachelorsDegreePRC + \beta_1 PopulationDensity + \beta_3 MedianIncome + \beta_4 MarijuanaUse$$

Table 4:

Medical Marijuana Law Dummy	Coef.	Std. Err.	T	P
Bachelors Degree Percentage	-0.0276854	0.0079397	-3.49	0.001
Population Density	0.0061687	0.002444	2.52	0.015
Median Income	0.0327159	0.0075696	4.32	0.000
Marijuana Use	0.0485821	0.0129522	3.75	0.000
Constant	-1.405018	0.3563571	-3.94	0.000

Because Medical Marijuana Laws are represented by a dummy variable, each coefficient is interpreted as a percentage change in the likelihood of marijuana laws. In this regression, every one percent increase in regular marijuana use for 18-25 year olds indicates an increase in the likelihood of medical marijuana laws in that state by 4 percent - not surprising considering the democratic process.

While these results are indicative of a link between marijuana use and medical marijuana, causation is still not certain considering the limited nature of the data. One argument may be that given medical marijuana laws, a larger portion of legitimate and illegitimate medical users will consume medical marijuana on a regular basis; this type of explanation argues that increased marijuana use is caused by medical laws. Another argument would be to say that populations

with high rates of marijuana usage are more likely to vote medical marijuana laws into existence; this type of explanation argues that medical marijuana laws are caused by populations with relatively higher marijuana usage.

It its likely that medical marijuana laws are not randomly distributed as roughly evidenced by the regression above. Although it should come as no surprise, there is a subtle implication involved. If medical marijuana laws cannot be determined to be random, differences in marijuana markets between states with and without medical marijuana laws are not necessarily caused by the laws themselves and may be due to preexisting structural differences in the marketplaces. This is not to say that we cannot be sure that medical marijuana laws have any effect on markets. As we've already explored, medical marijuana laws do significantly change the structure of cultivation, distribution and retail.

Estimating A Supply Curve:

Estimating a supply curve for all marijuana purchases will help us to understand the general market before distinguishing between medical marijuana market supply curves and others. Both price and quantity are equilibrium outcomes meaning that they are both simultaneously determined by supply and demand. We assume the supply equation takes the standard form: $Q_s = \beta_0 + \beta_1 Price + \beta_2 MMJ + \beta_3 High\ Quality + \beta_4 Low\ Quality + u$, we add the medical marijuana dummy to control for differences between the two presumably different markets. Demand quantity may be expressed by an equation similar to $Qd = \beta_0 + \beta_1 Price + \beta_2 Median\ Income + u$ where median income is positively correlated with quantity under the assumption that marijuana is a normal good.

Estimating the supply curve with two stage least squares requires the use of an instrument correlated with demand but not supply. In the first stage regression, median income proved to be correlated with price; with the additional reasonable assumption that median income is a demand

shifter and uncorrelated with price, median income serves as a good instrument for our two stage least squares supply regression.

Because the data from priceofweed.com is censored at one ounce, the dependent variable is truncated at the source of collection. In order to get better estimates from a censored variable, a tobit model with a right bound at one ounce can be used to test for robustness along with the results of OLS.

Table 5:

The results of the supply regressions not controlling for region with p scores in parenthesis

Grams	OLS	Tobit
Price	-0.51 (0.00)	-0.75 (0.00)
Medical Marijuana Laws	0.07(0.67)	0.16(0.54)
Low Quality	2.81 (0.00)	4.61 (0.00)
High Quality	2.11 (0.00)	3.21 (0.00)
Constant	18.27 (0.00)	23.74 (0.00)

Table 6:

Controlling for region

Grams	OLS	Tobit
Price	-0.54 (0.00)	-0.75 (0.00)
Medical Marijuana Laws	0.63 (0.00)	0.99 (0.00)
Low Quality	2.64 (0.00)	4.50 (0.00)
High Quality	2.25 (0.00)	3.20 (0.00)
Division 1	0.68 (0.11)	0.85 (0.20)
Division 2	1.18 (0.01)	1.55 (0.02)
Division 3	0.09 (0.78)	0.02 (0.97)
Division 4	0.36 (0.39)	0.54 (0.40)
Division 5	0.83 (0.01)	1.10 (0.03)
Division 6	1.39 (0.00)	2.14 (0.00)
Division 7	1.85(0.00)	2.87 (0.00)
Division 8	0.084 (0.78)	0.17 (0.73)
Constant	17.75 (0.00)	22.64 (0.00)

There are two distinct ways to interpret the results. First we will explore them under the assumption that what we are actually estimating is a production supply curve. Under this assumption, the results show a downward sloping supply curve; for every increase of one dollar, quantity falls somewhere between a quarter to two thirds of a gram. Although the results seem counterintuitive considering the traditional slope usually assumed to slope upward, there may be an explanation considering the illicit nature of marijuana.

The classic slope of the average cost curve is a U shape, sloping downward at smaller quantities. One explanation of a downward sloping supply curve considering the results would be to say that since a supply curve is derived from a firm's marginal cost curve, at lower quantities of production the supply curve actually does slope down. Due to the illicit nature of the marijuana market, suppliers may never reach minimum efficient scale. Marijuana cultivation is efficient in quantities not possible for the average illicit grower. It is estimated that costs minus

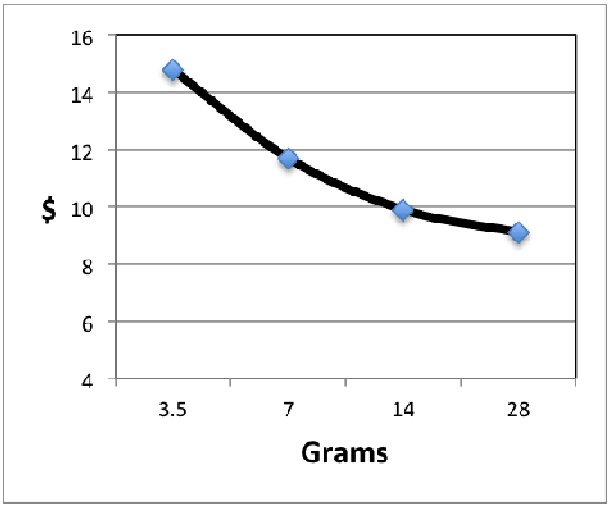
processing for a single, legal acre grow site could be as low as $70 per pound compared to a minimum of $215 for a 1500 square foot grow house. (Caulkins, 2010)

While the inability to reach minimum efficient scale is an elegant explanation, we cannot conclude that to be the case or exclude other possibilities because our data is truncated at the retail level. As we have specified in the regression equation, price is independent and quantity responds, however at the retail level it is likely that neither price or quantity are entirely independent of each other. Clements writes that marijuana exhibits certain similarities to other products in bundling and packaging which result in price breaks for increased quantities. (Clements & Zhao, 2009) A quick break down of average cost per gram relative to common packaged quantities reveals the following:

Table 7:

Quantity	Average Price Per Gram
Eigth Ounce	14.8
Quarter Ounce	11.7
Half Ounce	9.9
One Ounce	9.1

Graph 1:



Considering the transaction and transportation costs along with possible risks associated with distributing marijuana, retailers and distributers may offer price breaks for larger purchases

of marijuana. Preference for a slightly a lower margin but higher volume transaction that decreases associated transaction costs and risks would explain a downward sloping retail level supply curve independently of any possible production factors. In an illicit market place, each transaction exposes both parties to risk and each transaction also imposes a cost on the distributer because, if nothing else, transactions take time to complete. If it were true that distributers were adverse to increased implicit costs and risk, we would expect to see markets with lower transactions costs and risk associated with a transaction exhibit a less steep, flat or possibly positively sloped supply curve.

Differentiated Supply Curve:

Regional markets with medical marijuana laws and quasi-legitimate forms of distribution may exhibit an upward sloping, flat or less steep downward sloping supply curve for several reasons. The medical marijuana market as earlier shown to have a downward effect on marijuana prices in some markets must allow for some legal avenues of cultivation and distribution which may be more efficient because of larger operations. Additionally and more relevant to our data, with established retailers and less damning laws, transactions costs and risk may be less of a determinant of price in a retail market.

Creating an interaction variable between medical marijuana laws and price effectively separates out the supply curves of medical marijuana states and those without the laws. If the assumption that medical marijuana states have a different supply curves holds, then we would expect to see an additional statistically significant, negative coefficients on the interaction and price variable. Adding it to the instrumented regression equation we should expect a less downward sloping supply curve with price plus the interaction term than with just price alone.

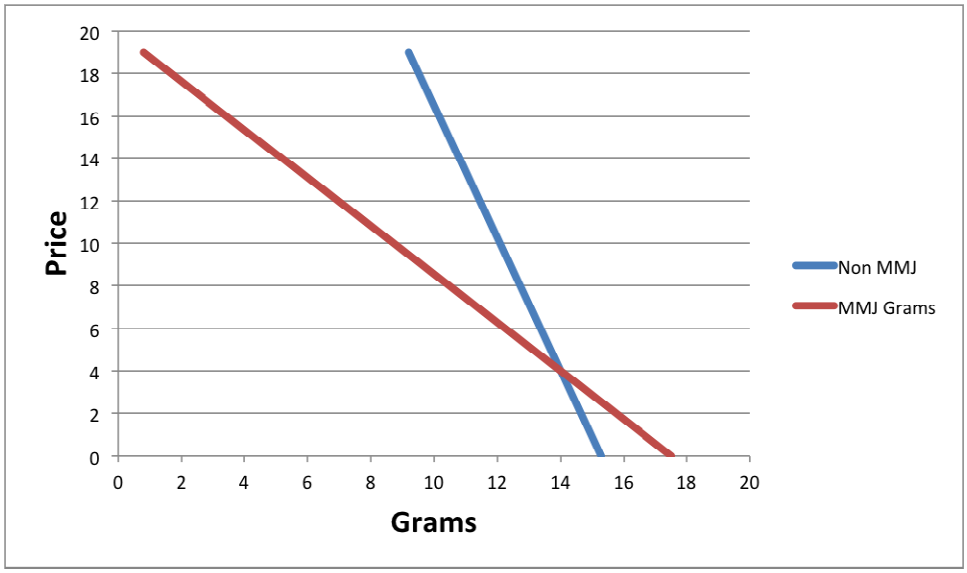
Equation:

Price is instrumented with median income as in the first equation.

Table 9:

Grams:	OLS	Tobit
Price	-0.29 (0.01)	-0.43 (0.02)
Medical Marijuana Laws	7.20 (0.00)	10.73 (0.00)
Medical Marijuana Price Interaction	-0.61 (0.00)	-0.90 (0.00)
Low Quality	3.27 (0.00)	5.30 (0.00)
High Quality	1.63 (0.00)	2.49 (0.00
Constant	15.87 (0.00)	20.15 (0.00)

Graph 2: A visual representation using OLS estimates



All results are statistically significant and give expected signs. The results here indicate that in states with medical marijuana laws, suppliers are operating on a less steep supply curve. This is consistent with earlier conjectures that medical marijuana laws may serve to lower transactions costs along with risk associated with distribution, thereby lowering the incentive to

provide price breaks for larger quantities.

Variance in Markets:

Earlier in the paper we posited that some medical marijuana laws have helped to make a more competitive marketplace. We assume that this is in part due to provisions that allow the establishment of dispensaries that decrease the cost to buyers and suppliers to distribute and seek information. If this is true we may expect to see less variance in price paid for purchases made in medical marijuana states. To get this information we will take u^2 from the first stage regression and regress all relevant variables including medical marijuana laws on the squared term. If medical marijuana laws do help to create a more competitive market and stabilize price, we would expect to see statistically significant negative coefficients associated with medical marijuana laws.

Table 10:

Variance	Coef.
Medical Marijuana Laws	-3278.86 (0.048)
Low Quality	-217.98 (0.922)
High Quality	-9939.01 (0.00)
Marijuana Use	-433.62 (0.051)
Median Income ($1000)	265.92 (0.003)
Population Density	30.59 (0.693)
Division 1	1930.19 (0.509)
Division 2	697.50 (0.759)
Division 3	156.56 (0.943)
Division 4	-280.20 (0.919)
Division 5	2422.81 (0.287)
Division 6	4784.21 (0.165)
Division 7	3768.37 (0.210)
Division 8	-2093.90 (0.373)
Constant	19722.98 (0.003)

When medical retailers or other distributers do not face the same risks associated with advertising and information as other distributers might, the costs of advertising go down and new

opportunities to distribute information arise. As distributers are able to disseminate information and users can find information more readily, buyers are better able to find lower prices and distributers are pressured to compete. Results from the equation suggest that medical marijuana laws reduce variance of price paid as do high and medium quality. These results give empirical weight to our argument that due to the institutional changes in markets caused by medical marijuana laws, price information becomes more readily available and prices are more stable.

Conclusion:

This paper provides empirical evidence of significant price effects of medical marijuana laws. Medical marijuana laws tend to decrease price, variance in pricing, and pricing breaks for larger purchases. Presumably downward effects on price are due to legalized avenues of production that increase supply, making marijuana comparatively cheaper than non medical marijuana states. We assume that decreased variance in pricing is largely due to the changes in market structure that medical marijuana laws allow, mainly that advertising and information seeking is less costly. Finally, we find evidence that the supply curve for medical marijuana is relatively less steep but still downward sloping compared to non-medical marijuana states, this is likely due to decreased transaction costs and risk associated with distribution that lessen incentives to provide bulk discounts. In seeking explanation for unconventional supply curve results, we have developed interesting but weakly supported hypothesis about the production supply curve beyond observations of one ounce, however due to our data limitations no conclusion can be reached.

As always, a more robust model is possible. In this case, time, resources and availability of data limit designing a panel data model that can track price changes in a given state before and after medical marijuana laws took effect. This would be a better way to argue causality between

laws affecting supply and the effects we see here. Additionally, observations beyond one ounce could give more accurate insights into a production supply curve that is likely different from the retail curve we are able to analyze with our data. Future papers might soon be able to look into the differences in regional production due to the soon to be instituted legal reforms which make producing marijuana legal and will likely make accurate data collection an easier task.

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