Estimating the Quasi-Underground: Oregon's Informal Marijuana Economy

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Abstract

*T*his study estimates the size of Oregon's informal marijuana economy, drawing upon Respondent-Driven Sampling (RDS) procedures and survey methods to investigate this quasi-underground activity. The results suggest that average marijuana users consume approximately 4.5 ounces per year and pay approximately $177 per ounce. Most users purchase the drug from friends and nearly one third of respondents indicate that they sell marijuana in small quantities. Growers tend to sell inauspicious quantities to friends and relatives, and rarely earn more than $10,000 annually from their sales. The composition of distribution networks suggests that the informal marijuana economy is a "robust network," particularly in states that allow personal medical production. This finding also suggests that legalization will likely produce a net increase in economic inequality, particularly affecting parts of Oregon associated with the State of Jefferson, by shutting out smaller producers. Several taxation schemes are presented to offer estimates of revenue if the drug were legalized; these findings suggest that marijuana could contribute modestly to the state's total revenue, but the most economically beneficial aspect of legalization could be from criminal justice savings.

Introduction

How much marijuana is produced, consumed, and sold in Oregon? How do users obtain their drug? How much does marijuana contribute to Oregon's economy? If legalized and taxed, how much revenue could the state reasonably expect to earn from the sale of marijuana? How might marijuana legalization impact current participants in this informal sector? This study estimates the size of Oregon's informal marijuana economy, drawing upon Respondent-Driven Sampling (RDS) procedures and survey methods to investigate this quasi-underground activity. By examining users and producers of marijuana, this analysis offers a unique contribution to our understanding of both informal economic participation and marijuana market structure in a key marijuana producing state. The results suggest that marijuana legalization is likely to increase economic inequality within Oregon's portion of the State of Jefferson.

Oregon has one of the highest rates of marijuana use in the US, with the most recent estimate indicating that 14.09% of individuals over 12 years old have used marijuana in the last year, with the average US rate standing at 10.2% (SAMHSA, 2009). Oregon is also home to

one of the oldest medical marijuana programs in the US, established in 1998, just two years after the first was created in California, and publishes county-level counts of medical users dating back to 2005. The counties traditionally associated with the State of Jefferson have the highest per capita rates of participation in Oregon's medical marijuana program (see Figure 1) and are likely more economically sensitive to marijuana regulation than other areas of the state (Crawford, 2013). Oregon consistently ranks in the top 10 states for plants seized by the Drug Enforcement Administration, with estimates of production valued at $473 million in 2005, making it the state's largest agricultural commodity (Gettman, 2006). Even with a firmly entrenched federal prohibition on marijuana, there is a strong possibility that Oregon's quasi-legalization (through its medical program) makes the likelihood of more candid responses from respondents possible; additionally, the lack of an established legal means of selling medical marijuana in Oregon suggests that traditional models of distribution may still be in effect—therefore, the results should be extrapolatable to non-medical states.

With two states fully legalizing recreational marijuana use in 2012 and repeated calls from anti-prohibitionists to tax and regulate marijuana production, distribution, and
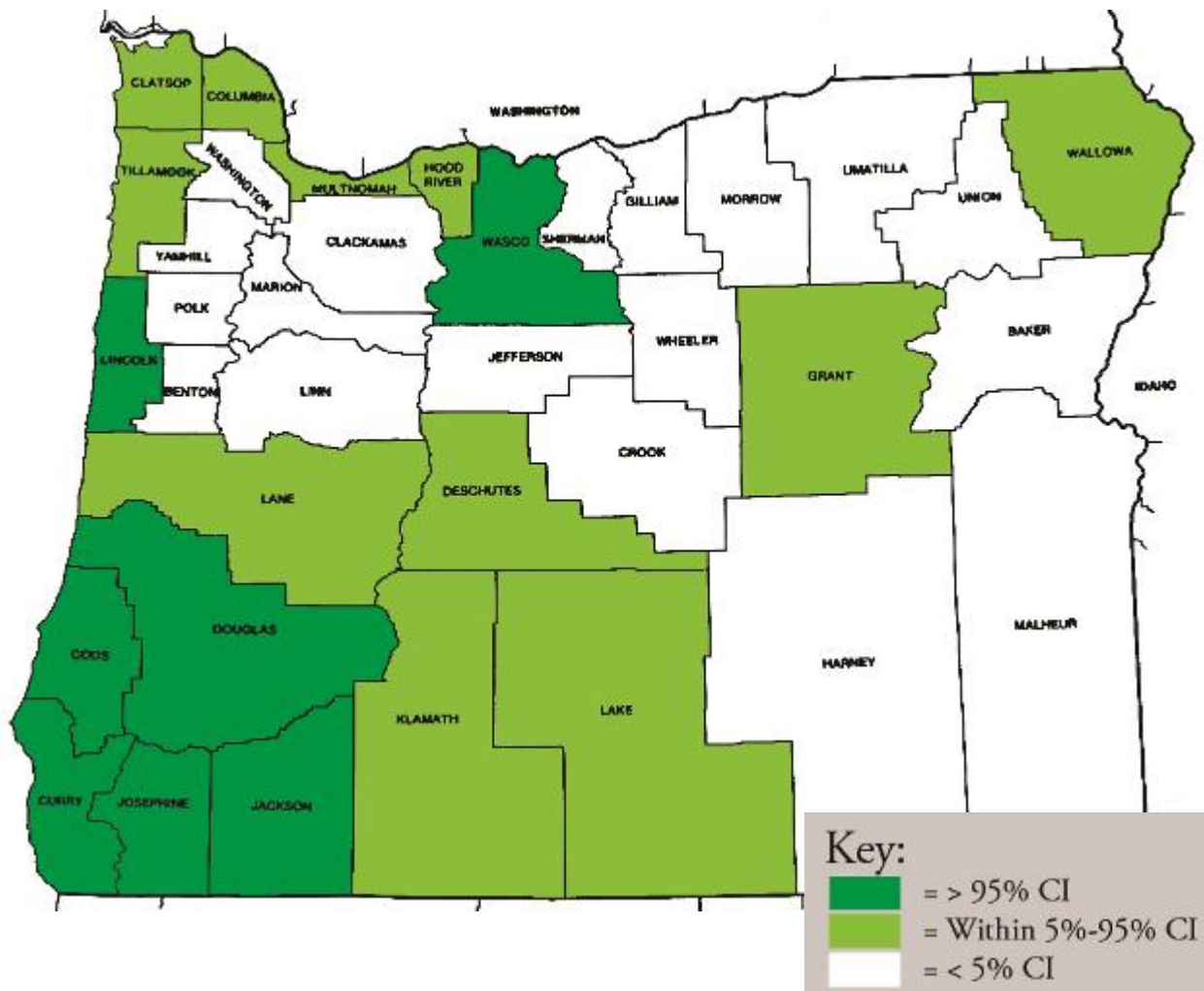

Figure 1. Oregon medical marijuana patients per 1,000 residents, by county, 2012 (data from the Oregon Health Authority).

consumption, it is very important to have a more thorough understanding of marijuana market dynamics—particularly the roles that various actors play within marijuana distribution networks. This study describes the literature surrounding informal economies and methods of measuring them, generates a sample of Oregon marijuana users and producers using RDS methods, and surveys the resulting sample to examine the size and composition of Oregon's informal marijuana economy.

Literature Review

The term "informal economy," first introduced by Hart (1973), defines the set of economic transactions outside of state regulation. Much of the same activity would be part of the formal economy if its actors registered their business, sales, or services and paid state licensing fees, insurance costs, and taxes. Informal economic activity—alternately referred to as the shadow or underground economy—consists of a wide range of types, such as unpaid or off-the-books labor, bartering, manufacturing, and distribution of drugs, weapons, counterfeit goods, and information, as well as a multitude of illegal services (sex, financial arrangements, waste disposal, security, etc.). Informal economies are widely viewed as the dominant mode of production in developing nations, but viewed as a place of last resort for those marginalized within developed countries—although reality is much more complicated than a simple dichotomy. Recent studies have demonstrated that shadow economies are growing in size in many nations, though for a multitude of reasons specific to individual countries (Schneider & Enste, 2000). With their existence derived from, and shaped by, the formal economy, shadow economies offer interesting opportunities to understand the dynamics of labor markets and the rationales of individuals participating in them.

The primary theoretical explanations for actor behavior or market dynamics in informal economies include dual market theory and bureaucratization theories, though both are underpinned by an assumption of rationality on the part of actors.

Dual market theory, elaborated by Reich et al. (1973), posits a bifurcation of the economy into primary and secondary labor markets. The primary market is characterized by more stable, higher-paying jobs, often with the possibility of promotion. Within the primary market, desirable occupations are further segregated by race and gender, with white male workers inhabiting the most desirable jobs. The secondary market encompasses a broad swath of the remaining workforce (but primarily consists of women, minorities, and youths), including in its ranks low-skilled white collar, blue collar, and service industry jobs, as well as all other informal occupations (legal or otherwise). Constructing the theory as an historical explanation of US labor market structure, Reich et al. contend that this segmentation was not accidental, but was a component of the trajectory of monopoly capitalism (see also Baran & Sweezy, 1966). Labor force homogenization and growing union politicization collided with new manufacturing technology and a necessity for oligopolic capitalists to maintain monopolistic control over commodity and labor markets. Large firms were able to divide their workforce through specialization, union busting, and promotion opportunities to well-paying jobs (instilling an appreciation for bureaucracy). Lesser firms and sectors—those on the "industrial periphery"— were more unstable and tended to employ less stable employees (Reich et al., 1973).

Bales (1984) expands this notion into the criminal economy, positing that another dichotomy exists within this subsector of the secondary economy. Bales assumes that the tendency of criminologists to focus on arrested individuals as representative actors of the criminal economy is problematic due to selection bias. Instead, Bales suggests that a similar

opportunity structure to the primary sector exists within the world of crime, with lower-level criminals prone to high turnover and unstable working conditions, and higher-level criminals enjoying more stable employment and prospects for advancement (1984, p. 147). A key explanatory variable in this approach is the availability of investment capital; achieving stability in the underground economy is highly dependent upon owning the (illegal or quasi-legal) means of production.

In both cases, individuals within the secondary labor market come to view the informal economy as a supplement to unsteady conditions in the formal economy and rationally choose to participate in the former. While helpful in understanding the historical conditions behind divergent labor markets in the US, this theoretical tradition does not offer a nuanced description of specific causal forces driving informal market participation.

Bureaucratization theories primarily focus on political and economic structural forces that influence the size and composition of informal markets. Tax and social security burdens, intensity of regulation, social welfare transfers, regulation and cost of labor, and quality of public sector services are primary influences on the size of a nation's informal economy (Schneider & Enste, 2000). As tax burdens, public assistance, and public services increase in a nation's formal economy, shadow economies are said to increase in size and complexity. Firms respond to these particular forces by cutting their labor costs (reduction of hours and benefits, layoffs, and consolidation), and individuals (again) rationally augment their lost income by entering the informal economy in various manners. The extent of participation in the informal sector is difficult to assess and left unaddressed by this theoretical tradition; bartering, working under the table, and manufacturing illegal goods are not qualitatively equivalent in their intensity. Despite significant shortcomings, the approach offers several innovative methods for calculating the relative size of informal markets within a country.

Methods of Calculating Underground Economy Size

Arriving at an accurate estimate of total activity for any economic sector is problematic. The difficulty is obviously greater with informal activity, illegal or otherwise. A number of studies have attempted to estimate the size of underground economies; the approaches vary, but are—due to data availability—generally applied to national economies and include direct micro-level surveys (Pahl, 1984; Barthe, 1985; Leonard, 1994; Lin, 1995; Phizacklea & Wolkowitz, 1995), indirect monetary measures (Henry, 1976; Feige, 1979; Tanzi, 1980; Meadows & Pihera, 1981; Matthews, 1982; Cocco & Santos, 1984; Matthews & Rastogi, 1985; Weck-Hanneman & Frey, 1985), and indirect non-monetary measures (Lizzeri, 1979; Alden, 1982; Del Boca & Forte, 1982; Denison, 1982; Portes & Sassen-Koob, 1987; Castells & Portes, 1989; Kaufmann & Kaliberda, 1996; Portes, 1996; Johnson, Kaufmann, & Shleifer, 1997; Lackó, 1998; Lackó, 2000; Schneider & Enst, 2000).

I use a direct micro-level approach in this study. Critics of this approach question the willingness of respondents to provide potentially incriminating information about their activities, leading to a downward biasing of results. Counter to this criticism, Pahl (1984) found that interviews with both suppliers and consumers of underground goods resulted in equivalent levels of informal participation, and others (Leonard, 1994; MacDonald, 1994; Evason & Woods, 1995; Fortin et al., 1996) noted an inherent willingness of respondents to discuss their participation (as both producers and consumers of informal goods and services). The most glaring difficulties of direct surveys is meaningfully extrapolating the results of a narrow sample to a larger geographic area and locating willing respondents (especially in the context of

illegal activities). Details on why this approach is selected over competing methodologies (particularly those outlined above) are more fully explicated in Crawford (2013).

Accessing hidden populations—a status to which marijuana users, producers, and sellers are primarily relegated in the United States—poses two unique challenges to investigators; as Heckathorn notes,

> First, no sampling frame exists, so the size and boundaries of the population are unknown; and second, there exist strong privacy concerns, because membership involves stigmatized or illegal behavior, leading individuals to refuse to cooperate, or give unreliable answers to protect their privacy. (1997, p. 174)

To address these concerns, researchers have traditionally relied on snowball sampling, key informant sampling, and targeted sampling to investigate hidden populations. The shortcomings of each approach are detailed elsewhere (Heckathorn, 1997), but the primary concern is derived from the lack of independence between observations, which is an unassailable artifact of snowball and targeted sampling. Heckathorn's (1997; 2002; 2007; Volz & Heckathorn, 2008) Respondent-Driven Sampling (RDS) offers an elegant addendum to chain referral procedures by limiting the number of potential recruits that each respondent can bring into a research program and incorporating both primary and secondary incentive structures into the recruitment process. Respondents are rewarded for participating in the study (i.e. completing a survey or interview), but also receive rewards for referring others to the research program.

When combined with controls to verify that a prospective respondent is a member of the targeted population, the collection of successive waves of respondents leads to "an equilibrium mix of recruits…that is independent of the characteristics of the subject or set of subjects from which recruitment began," allowing for the calculation of unbiased population estimates (Heckathorn, 1997, p. 183; see also Salganik & Heckathorn, 2004; Wejnert & Heckathorn, 2008; Wejnert, 2009). RDS operates under four assumptions: (1) respondents accurately describe the size of their personal network within the sample population; (2) recruitment of additional respondents involves random selection by recruiters from their personal networks; (3) friendship ties are reciprocal; and (4) recruitment operates as a Markov process in that the transition probabilities of the last individual recruited converges towards an equilibrium (achieved when that individual's probability of selection is proportional to their personal network size) (Volz & Heckathorn, 2008, pp. 82-84). In the process of achieving equilibrium, key variables of interest (race, gender, or other theoretically specified statuses) are monitored throughout the recruitment process. This approach is successfully implemented in the study of intravenous drug users (Heckthorn, 1997; Heckathorn et al., 2002), AIDS patients (Heckathorn et al., 1999), men who have sex with men (Ramirez-Valles et al., 2005), sex workers (Johnston et al., 2008), Canadian marijuana users (Hathaway et al., 2010), and studies of jazz musicians (Heckathorn & Jeffri, 2001).

Previous studies relying on RDS required interviewers, a physical location from which to operate, printed recruitment coupons, and a coupon tracking system; while the face-to-face interaction helps explain why referral rates are so high in these studies, significant limitations arose when assembling samples. Researchers, regardless of their constitution and efficiency, can only interview so many people in a single day, interview locations are not available at all times, and respondents' schedules do not always correspond with researchers'. Web-based RDS

(webRDS) eliminates many of the logistical problems (though introducing new and complicated replacements), and tends to increase the speed of sample gathering (Wejnert & Heckathorn, 2008; Bengtsson et al., 2012; Bauermeister et al., 2012).

Though unaddressed by Wejnert and Heckathorn (2008) due to the nature of their study, webRDS poses an additional complicating feature with hidden populations, particularly those who are security conscientious—that of providing anonymous financial incentives. Limiting or completely eliminating monetary incentives to participants is one method of maintaining anonymity; however, no one has attempted an RDS study of this nature. This study, in addition to investigating marijuana users in Oregon, attempts the first non-monetary primary incentive RDS implementation.

Methods

To answer the research questions posed in this study, I developed a webRDS protocol and web-based survey to examine a sample of marijuana users in Oregon. To investigate the role of different secondary incentive types in the success of RDS studies and to protect respondents' anonymity, I chose to forego all monetary payments. Instead, multiple non-monetary secondary incentives were implemented: (1) prospective respondents were appealed to based on the potential political and economic importance of examining their population; (2) live updates and total network referral counts for each respondent were posted on a website to encourage competition among participants to recruit others; and (3) respondents were granted access to near-live aggregate data and summary statistics as the project developed.

Respondents were eligible to participate if they were Oregon residents, over the age of 18, used marijuana in the last year, and received a unique study ID from a previous participant in the study. The web-based survey instrument included a question that tracked study IDs; any previously used IDs were barred from reuse. After completing the survey, respondents were redirected to another web page with instructions about the referral process, as well as links to five additional recruitment letters (in PDF format) that could be downloaded and shared with prospective recruits by email, Facebook, or instant message.

I identified a single "super seed" with a very large number of friends who are users, producers, and sellers of marijuana in several counties identified as "areas of interest" within Oregon (Benton, Josephine, and Multnomah counties). The super seed was fully briefed on the project, the referral process, and the importance of collecting chain referrals by following up with prospective respondents. The seed successfully recruited 26 respondents in the second wave from 10 Oregon counties. However, the lack of monetary incentives and the format of the recruitment letters appear to have quickly affected recruitment rates compared to previous RDS studies (web-based and traditional), as the referral process died out with only 72 respondents (five waves). The implications of this finding are discussed later in this study and more fully detailed in Crawford (2014).

Survey Instrument

The survey instrument collected self-reported information on (1) individual characteristics, such as gender, age, height, weight, frequency of exercise, county of residence, ethnicity, political party membership, education level, employment status, relationship status, occupational category, health insurance coverage, number of close friends, and income; (2) marijuana-related questions, including frequency of use, reasons for use, medical license status and roles, number of close friends who use, reasons for growing, number of plants growing,

method of growing, source and reimbursement rate for obtained marijuana, amount consumed, and the perceived acceptance of marijuana use by immediate social circle and local community; and (3) a detailed political orientation index (using a replication of the 2011 Pew Political Research political typology questionnaire). Ordinary least squares (OLS) regression is used to identify variables associated with marijuana use amount. These results are then used to predict Oregon's total marijuana demand, estimate the economic value of Oregon's marijuana market, and provide several tax revenue projections if the drug were to be legalized. The full survey instrument is available in Crawford (2013).

Results

This section addresses how marijuana is obtained in Oregon, who sells and produces the drug (including their rationales for doing so), and provides an evaluation of illegal marijuana sales' impact on Oregon's economy. The lack of monetary incentives severely hampers the recruitment process, as the final sample consisted of 72 respondents and took approximately two months to gather from the initial referral. This finding represents an important addition to the growing RDS literature on its own. The small sample size approached, but did not fully reach, equilibrium; this impinges on the generalizability of the findings collected in this study (Heckathorn, 1997; Crawford, 2014). Even with these limitations, the results offer some important insight into the population of Oregon marijuana users, particularly relating to the structure of small-scale marijuana distribution networks.

Obtaining Marijuana: Sources, Use Amount, and Costs

Where do users obtain the drug? Respondents were asked to identify all of the sources where they received or purchased marijuana in the last year; this information is presented in Table 1, divided along Oregon Medical Marijuana Program (OMMP) participation status. Friends, the black market, and medical growers are the most widely cited sources of marijuana in Oregon. Licensed medical users, as a group, appear to be the most self-sufficient, though they still rely on other medical growers or friends. Most non-licensed users obtain the drug from friends, the black market, and medical growers.

Table 1. Sources of marijuana for users and OMMP status.

OMMP Participant	Self	Black Market	Dispensary	Medical Growers	Friends	Other
No	4	25	1	14	34	3
Yes	12	3	5	7	6	0
Total	16	28	6	21	40	3

The majority of respondents use less than 20 grams per month, though a handful of outliers consume 2-3 ounces over the same period. Men, at first glance, appear to use significantly more than women (19.6 grams vs. 11.1 grams); however, all of the extremely heavy users are men. If the major outliers (n=4) are dropped, men average 11.8 grams per month—or roughly the same as women—though it is important to note that all of these heavy-using outliers are men (note: all subsequent calculations in this study do not exclude these outliers). Assuming a per month average use rate of 15.94 grams (the mean in this sample), each marijuana-using adult in Oregon will consume approximately 6.75 ounces per year; with an estimated 550,000 users in Oregon, this suggests that the state requires over 231,935 pounds

of processed marijuana to meet the market's demand. Determinants of monthly marijuana consumption are presented in Table 2.

Table 2. OLS regression models estimating marijuana use amounts.

Variable	Model			
	1	2	3	4
OMMP Cardholder (0=no, 1=yes)	17.99*** (4.72)	16.30*** (4.55)	5.40 (4.98)	----
Gender (0=male, 1=female)	----	-8.49* (4.35)	-9.67* (3.93)	-10.24** (3.87)
Age (18-100)	----	-.19 (.24)	.04 (.26)	----
Education (1-5; 1=some high school, 5=master's or above)	----	-4.75* (2.02)	-5.34* (1.99)	-5.45** (1.92)
Income (0-8)	----	----	$-.12^{e-3}$ $(.81^{e-4})$	$-.13^{e-3}$ $(.69 e^{-4})$
Children in home (0=no, 1=yes)	----	----	11.21* (4.62)	12.26** (4.48)
Age at First Use (0-100)	----	----	-2.45** (.75)	-2.82*** (.64)
Constant	11.18 (2.43)	38.12 (9.85)	78.50 (15.57)	87.10 (13.20)
$n =$ (Adj. R^2)	68 (.16)	68 (.25)	62 (.35)	62 (.37)

* $p > .05$, ** $p > .01$, *** $p > .001$

Holding a medical license is associated with much higher usage—about 17 grams more per month—before controlling for age at first use. Age at first use is negatively related to monthly consumption; in this context, each additional year of waiting before trying marijuana for the first time leads to a reduction of 2.4-2.8 grams in total monthly consumption for those who continue using the drug. Higher levels of education are associated with a monthly reduction of 5 grams per category of education completed (1=some high school, 2=high school graduate, 3=some college, 4=college graduate, 5=master's or above). Having children in the home is positively related with monthly use amounts; in the final model (4), this variable has the greatest overall effect on use amounts (12 grams). Women, on average, consume 9-10 grams less marijuana per month than men; however, as mentioned above, this finding is highly sensitive to the inclusion of profligate users (who are all male). Age and income do not appear to be related to total monthly marijuana use, although more data is necessary to strengthen the robustness of these findings.

The average price paid per ounce of marijuana is $177 (std. dev.: $91; n=57). Interestingly—and contrary to the claims of many law enforcement officers and policy

makers—there is not a statistically significant relationship between the per capita rate of OMMP cardholders and marijuana prices in Oregon counties (see Figure 1), though the coefficient is negative and small (-2.37; p = .072; Adj. R2: .04) in univariate regression tests. It would be logical to assume that individuals paying less than $50 per ounce are members of the OMMP and receive the drug at-cost from licensed growers (as specified in the Oregon medical marijuana law); however, data indicate that all eight of these people are illegal users, obtain the drug from "friends," and use the sample's average amount of marijuana per month (15 grams). This finding—which is further supported by anecdotal statements from those involved in marijuana production—suggests that there is a bifurcation in this particular market between medium and small buyers/sellers. Additionally, the price paid per ounce could also be a function of social proximity; close friends and family may receive steep discounts or free marijuana, while others pay market price. While there is little difference in the mean price reported by OMMP participants and illegal users ($0.11), the variation in prices are significantly greater for non-medical users (std. dev.: $103 vs. $53) (see Figure 2).
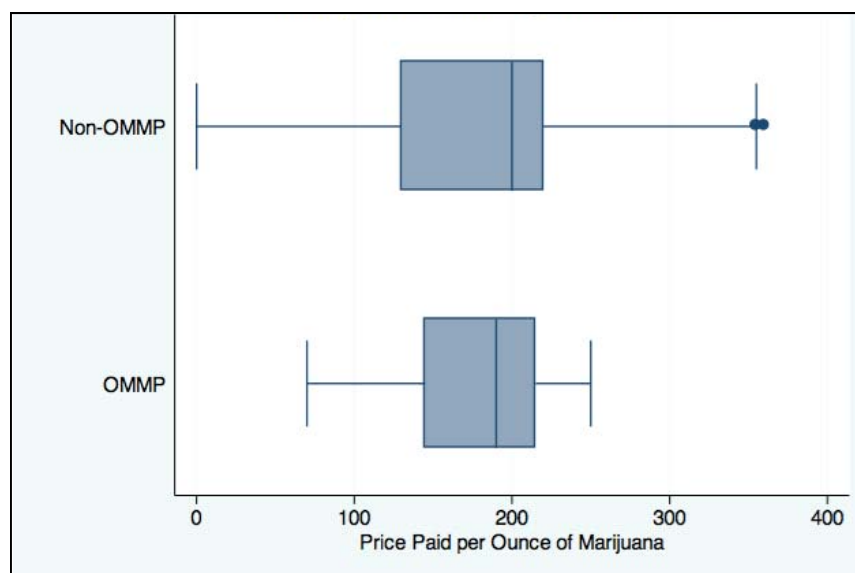

Figure 2. Marijuana prices by OMMP status.

Illegal users have a greater chance of both paying more for their drug than licensed medical users and receiving steep discounts. This is likely a function of the amount of marijuana consumed by medical patients and their access to quasi-legitimate sources of the drug. Illegal users who consume small amounts report paying little to nothing for their supply, but more regular users pay much more.

Who Sells and How Much?

More than half (52%) of respondents (n=38) have sold marijuana at some point in their life. Those who have sold are disproportionately male (76%), educated (76% hold a bachelor's degree or above), and are much more likely to have a criminal record than other respondents. In fact, of the 16 respondents who have been arrested, 15 have sold marijuana and eight have been arrested on marijuana-related charges. Those who begin using the drug at an early age are slightly more likely to have sold during their lifetimes. Current use amounts are also positively related to lifetime selling events, though the effect is small. There is no relationship between

having sold marijuana and an individual's political ideology, size of close friends network, ethnicity, income, or relationship status.

One third (n=24) of respondents have sold marijuana in the past year. Three fourths of recent sellers are male, 66% hold a bachelor's degree or above, and 91% are employed. The relationship between the number of ounces sold and an individual's income are not statistically significant, though the coefficient is negative; this suggests that sellers of marijuana are either not making a profit, under-reporting their actual income, using sales to offset their own use, or attempting to use marijuana sales to buttress lower-than-average incomes. The mean annual income of recent sellers is lower than those who have not sold ($28,937 vs. $34,975), which provides support to the possibility that selling is used as an adjunct income source for employed, low-wage earners or simply offsets the cost of personal use. Of the 24 recent sellers, 14 are participants in the Oregon Medical Marijuana Program (OMMP); restated in slightly different terms, 18 of the respondents are participants in the OMMP program and 14 of those sold in the last year. Ten of the 14 individuals who have sold more than one pound of marijuana in the last year are participants in the program as well (see Table 3).

Table 3. Marijuana Selling and OMMP Participation.

Ounces Sold in Last Year	OMMP Participant?		Total
	No	Yes	
15 or less	6	4	10
16-48	3	6	9
49 or more	1	4	5
Total	10	14	24

The groupings present in Table 3 can be elaborated further by examining the aggregate amount of marijuana sold: the first group (n=10) sold 51 ounces, the second group (n=9) sold 253 ounces, and the third group (n=5) sold 850 ounces. The top three sellers moved nearly an equivalent amount of marijuana through the underground economy as all other sellers combined (544 ounces vs. 559 ounces). Though it sounds like a lot of marijuana (69 pounds), the magnitude of these sales must be contextualized in relation to the total demand in Oregon. The amount of marijuana reportedly sold by respondents in this study would meet the personal needs of 245 average users, with an overall consumer/seller ratio of approximately 10:1.

Who Grows and Why?

Sixteen respondents admit to growing marijuana; 12 of those are participants in the OMMP and four produce the drug without state protection. Growers from this study sold a total of 721 ounces (mean: 45 ounces per grower; non-growers sold a total of 433 ounces) of marijuana in the last year for a mean price of $175 an ounce. Limited data obviously hampers the generalizability of these findings, but the results do provide an interesting window into demographic characteristics of growers, rationalizations for growing, and the size of production operations. Thirteen of the 16 growers are male; 11 of the 16 hold a bachelor's degree or above; 14 are employed; average age is 31 years; all but one is white; and all are either married or in a stable relationship. The ranked rationalizations for growing offered by these producers are presented in Table 4. Self-reliance is the highest ranked and most cited reason for growing, followed closely by "enjoy gardening." There appears to be a strong ideological commitment to

Table 4. Counts and ranks of reasons for growing.

Reason	n	Mean rank	n ranked as #1	
			Medical	Illegal
Being Self-Sufficient	12	1.75	6	2
Enjoy Gardening	12	2.66	1	0
Marijuana's Positive Impact	10	2.9	2	2
Helping Others in Need	8	3.75	0	0
Black Market Avoidance	8	4.25	0	0
Commitment to Freedom	6	4.5	0	0
Spiritual Aspects	5	4	0	0
Making Extra Money	4	4.5	0	0
Business Challenge	2	6.5	0	0

n=13

the notion that marijuana has a positive impact on people's lives, as well as to helping other people in need (by extension, marijuana is viewed as fulfilling this unmet need). Surprisingly, making extra money or engaging in production because of the business challenge involved are the least cited and lowest ranked of all rationalizations, despite the fact that 14 of the 16 growers claimed to have sold marijuana in the last year.

Most growers use both indoor and outdoor methods to produce marijuana (n=9); two exclusively grow outdoors and five only grow indoors. The mean plant counts reported—i.e. the average number of plants (seedling, vegetative, and flowering) grown at one time—is 18.5 (std. dev.: 12.8; min: 4, max: 50). All respondents who grow marijuana would be considered small-scale producers by previous researchers (Weisheit, 1992; Decorte, 2010). The mean gross revenue generated by marijuana sales annually by these growers ($7,800) supports the "small-scale" designation as well, particularly when larger producers (n=2) are excluded; in that case, the gross revenue drops to $2,971 per grower.

Marijuana and Oregon's Informal Economy

How much marijuana is consumed and produced in Oregon, and how large is its informal marijuana economy? As noted above, estimations suggest that around 550,000 adult Oregonians use marijuana each year (SAMHSA, 2009), and data collected in this study indicate that the average user consumes 6.75 ounces a year—using these figures, Oregon requires about 154,000 pounds of marijuana to meet its internal demand. At an average reported price of $177 per ounce, this internal market would generate more than $436 million in revenue per year, making it Oregon's third most valuable commodity (Oregon Blue Book, 2011). An important point to note is that these are estimates of Oregon's internal marijuana market size; if exports to other states were included, this figure is likely to be much larger. Using data gathered in this study offers the possibility of a slightly more nuanced projection of marijuana's contribution to Oregon's informal economy; unfortunately, the RDS sample constructed for this study did not attain equilibrium, so accurate population estimates are not possible. On the other hand, enough data were collected to offer tentative econometric projections (which should be reexamined in a fully-funded study of this population).

Demand

Estimates for Oregon indicate that 10.27% of individuals 26 or older have used marijuana in the last year, and 6.58% used in the last month; for persons in the 18-25 age category, 36.96% used in the last year and 21.9% used in the last month (SAMHSA, 2009). Marijuana demand models can be constructed using population estimates for these age groups (18-25 year old and 26 or older) and the survey-derived use amounts associated with each category of user (with per month results multiplied by 12 to attain yearly figures). The model is expressed as:

(1) Marijuana Demand Model

*D = (((18-25 POP * %Users) * Amount) + ((>26 POP * %Users) * Amount)) * 12*

Total annual adult demand is 12 times the monthly demand by young adult users between the ages of 18 and 25, plus 12 times the monthly demand by older users aged 26 and older. The monthly demand for each age group is equal to the number of users multiplied by the average amount used. Separating light users (operationalized as individuals who use once a month or less) from heavy users (operationalized as using multiple times each month) and applying the formula above to each resulting group can further specify the total marijuana demand in Oregon:

(2) Light User Demand Model

*D = (((265,677 * .15) * 1.75g) + ((2,701,901 * .0369) * 3.25g)) * 12*

The light-demand model is equal to the sum of light, young user consumption and light, older-user consumption. For young users, this is the population aged 18 to 25 (265,677) times the portion that lightly uses marijuana (15%), multiplied by the average use in this age group (1.75 grams). For older users, this is the population aged 26 or older (2,701,901) times the portion that lightly uses marijuana (3.69%), multiplied by the average use in this age group (3.25 grams). The aggregate monthly demand (393,765 grams) is then multiplied by 12 to arrive at yearly demand figures (4,725,180 grams), which is equal to 10,417 pounds at a conversion of one gram per 0.00220462 pounds.

(3) Heavy User Demand Model

*D = (((265,677 * .219) * 22.4g) + ((2,701,901 * .0658) * 17.6g)) * 12*

The heavy-demand model is equal to the sum of heavy, young-user consumption and heavy, older user consumption. For young users, this is the population aged 18 to 25 (265,677) times the portion that heavily uses marijuana (21.9%), multiplied by the average use in this age group (22.4 grams). For older users, this is the population aged 26 or older (2,701,901) times the portion that heavily uses marijuana (5.58%), multiplied by the average use in this age group (17.6 grams). The aggregate monthly demand (4,432,322 grams) is then multiplied by 12 to

arrive at yearly demand figures (53,187,864 grams), which is equal to 117,259 pounds at a conversion of one gram per 0.00220462 pounds.

Using this approach, the total amount of marijuana demanded in Oregon for 2012 was approximately 127,676 pounds, which translates to $361 million (using the average price per ounce of $177). This is a smaller estimate than was derived from mean usage data.

Separating medical users out of the aggregate user population can further specify demand models. This is the case because (1) light medical users consume less than their unlicensed counterparts and (2) heavy medical users consume more than their unlicensed counterparts. In both situations, isolating medical users should lead to a smaller (and more accurate) aggregate demand figure. About 55,000 individuals are registered with the state as legal medical users; data collected in this study suggests that 11% are between the ages of 18 and 25, 11% meet the criteria for "light users," and usage rates vary between unlicensed and licensed using populations. The augmented demand models are:

(4) Light User Demand Model + Medical Users

*D = (((265,677 * .15) * 1.75g) + ((2,701,901 * .0369) - 6,050) * 4g) + (6,050 * 1g)*

The "light-demand model + medical users" is equal to the sum of light, young-user consumption and light, older-user consumption. For young users, this is the population aged 18 to 25 (265,677) times the portion that lightly uses marijuana (15%), multiplied by the average use in this age group (1.75 grams). For older users, this is the population aged 26 or older (2,701,901) times the portion that lightly uses marijuana (3.69%), minus the number of 26 or older light medical users (6,050), multiplied by the average use in this age group (3.25 grams) —the result is then combined with the number of light medical users (6,050) times their average use (1 gram). The aggregate monthly demand (450,391 grams) is then multiplied by 12 to arrive at yearly demand figures (5,404,692), which is equal to 11,915 pounds at a conversion of one gram per 0.00220462 pounds.

(5) Heavy User Demand Model + Medical Users

*D = (((265,677 * .219) - 6,050) * 20.54g) + (((2,701,901 * .0658) – 42,900) * 10.4g) + (6,050 * 33g) + (42,900 * 32.6g)*

The "heavy-demand model + medical users" is equal to the sum of heavy, young-user consumption and heavy, older-user consumption. For young users, this is the population aged 18 to 25 (265,677) times the portion that heavily uses marijuana (21.9%), minus the number of 18 to 25 year-old heavy medical users (6,050), multiplied by the average use in this age group (20.54 grams). For older users, this is the population aged 26 or older (2,701,901) times the portion that heavily uses marijuana (5.58%), minus the number of 26 or older heavy medical users (42,900), multiplied by the average use in this age group (10.4 grams). The result is then combined with the product of 18 to 25 year-old medical users (6,050) and their use amount (33 grams), as well as the product of 26 or older medical users (42,900) and their use amount (32.6 grams). The aggregate monthly demand (4,071,812 grams) is then multiplied by 12 to arrive at yearly demand figures (48,861,744 grams), which is equal to 107,721 pounds at a conversion of one gram per 0.00220462 pounds.

This approach suggests that total demand is around 119,636 pounds, with a value of $339 million (using the average price per ounce of $177)—not as large as previous estimates, but still sizeable in relation to other commodities in the state. Demand from medical patients alone is estimated to be 42,441 pounds per year and valued at $120 million.

Supply

Estimates of marijuana supply are difficult to construct due to the small sample size obtained in this study (n=16). For example, 75% of medical users in this study produce their own supply (all are considered "heavy users")—if this were true for the population of Oregon medical users, total demand would be reduced by 31,927 pounds ($90.4 million). Additionally, most produce a small surplus (mean: 45 ounces per year). If this were an accurate depiction of the medical population of users, the quasi-legal production of medical marijuana in Oregon would supply the market (after meeting personal needs) with 140,508 pounds of the finished drug for $398 million in annual gross revenue.

Similarly, 6.9% of illegal users also grow marijuana without a license from the state. Three fourths of these growers are under 26 years old and are considered "heavy users." The mean amount sold in the last year by these producers is 16.5 ounces. Projecting these rates onto the estimated population of Oregon users yields 11,103 illegal growers (9,309 are 18 to 25 years old; 1,794 are 26 or older). Estimated production from these growers is approximately 11,450 pounds, which would produce gross revenue of $32 million per year. If self-sufficient, their production would also reduce aggregate demand by 4,827 pounds ($13.6 million).

Table 5 presents the estimated marijuana demand and supply figures for Oregon derived from the preceding equations. Demand estimates range from a low of 82,882 pounds (light + heavy + medical users, less self-sufficient growers) to a high of 231,935 pounds (using the mean use projections), with an estimated value ranging from $235 million to $657 million. Supply estimates are very rough projections due to the small number of growers identified in this study (n=16). Additionally, supply and demand estimates are highly sensitive to changes in self-sufficiency assumptions, particularly regarding medical users. Anecdotal evidence from within the Oregon medical community suggests that far less than 75% of patients produce their own marijuana, but more data is required to confirm this.

Table 5. Oregon marijuana demand and supply estimates.

Demand / Supply	Pounds	Gross Market Size
Demand		
Light / Heavy / Medical User, less Growers	82,882	$235 million
Light / Heavy / Medical User	119,636	$339 million
Light / Heavy User	127,676	$361 million
Mean Use	231,935	$657 million
Supply		
Medical Growers	140,508	$398 million
Unlicensed Growers	11,450	$32 million

Discussion

Even though the sample of Oregon marijuana users constructed for this study is not representative (RDS equilibrium was not achieved), the data collected offer several key insights into the structure and size of this particular informal economy and suggests policy changes are probably necessary.

Oregon decriminalized the possession of one ounce or less of marijuana to the level of a civil infraction—you can receive a ticket and pay a small fine—decades ago, but the sale of any amount of marijuana is still charged as a felony. Most marijuana users—legal or otherwise—obtain the drug from friends. This reconfirms decades-old research (Becker, 1963; Goode, 1970) and suggests that the buying and selling of personal quantities of the drug primarily occurs peer-to-peer, rather than "pusher-to-user." The importance of this finding cannot be overstated; if 33% of marijuana users sold the drug in the last year, this translates to approximately 181,500 Oregonians committing drug distribution felonies for the year. To put this figure in context, 19,262 were arrested on drug related charges in Oregon in 2011; further, a total of 133,414 adults were arrested in the state in 2011 (FBI UCR, 2011). This either means that law enforcement has dramatically failed to uphold Oregon laws or Oregon lawmakers have ignored the reality of drug distribution network topologies (or, more likely, both). Oregon marijuana distribution appears to meet "robust network" criteria in the dual sense that (1) many nodes are responsible for and take part in the exchange of this drug and (2) it "performs well in the face of attack" (Goyal & Vigier, 2010, p. 2). Lawmakers and law enforcers must take note: the criminalization of marijuana sales is an ineffective and piecemeal approach to controlling this substance—there is no centralized source to attack and there are too many active participants to incarcerate. If the goal is to control access to the drug, distribution should be centralized and overseen by the state (either directly or through licensure). Controlling production in a logically consistent fashion may not be possible under the current legal regime, as the medical marijuana program has legitimized and culturally entrenched small-scale, distributed production (and, as demonstrated in this study, most medical users/growers sell the drug, albeit in small quantities).

The situation is further complicated by rationalizations offered by marijuana growers: though the amount of marijuana produced and sold in the state likely rivals other top commodities, the vast majority of producers reportedly engage in this activity to help other people and are not attempting to earn a significant profit. Sales by growers seem to offset personal use costs, offset production costs, and make up for slightly lower than average incomes. This finding could be attributable, in part, to sampling bias, as all of the growers in this study are considered "small-scale" (fewer than 99 plants; all but two had less than $10,000 in annual sales). Even larger producers must exist to meet in-state demand; however, none were identified using the RDS procedure. The implications of this are profound: if a legalized distribution system were put into place with limited production licenses or mutually-exclusive tiers of operation (as has occurred in Washington), thousands of small growers would be locked out of this emerging market, while a few large-scale producers will reap most of the benefits. For a state with high unemployment and significant income inequality, it is difficult to envision this type of change as positive.

Proponents of legalization often cite potential tax revenue as a justification for altering the current legal environment. How much could the state of Oregon raise if the drug were legalized? The answer depends on the true market size, effective tax rates levied, retail price, and the proposed method of production and distribution. California's relatively laissez-faire

approach to medical marijuana (plant count limits are still in effect for producers) offers some insightful clues; levying a sales tax on medical marijuana at the final distribution point (dispensaries), the state raised between $58 million and $105 million in 2011 (Lifsher, 2011). Using the demand models constructed from this study's survey results (presented in Table 5), the estimates of tax revenue are offered in Table 6.

Table 6. Oregon marijuana tax revenue estimates.

Demand Model	Pounds	Total Tax / Gram	Revenue
Light / Heavy / Medical User, less Growers	82,882	$1	$37,594,687
Light / Heavy / Medical User	119,636	$1	$54,266,041
Light / Heavy User	127,676	$1	$57,912,928
Mean Use	231,935	$1	$105,204,071
Light / Heavy / Medical User, less Growers	82,882	$2	$75,189,375
Light / Heavy / Medical User	119,636	$2	$108,532,083
Light / Heavy User	127,676	$2	$115,825,857
Mean Use	231,935	$2	$210,408,143

With a total tax of $1 per gram, Oregon could see gross tax revenues increase between $37 million to $105 million per year. At $2 per gram, gross tax revenue generated would be between $75 million to $210 million per year. Even the lowest estimates are more than double the tax revenue obtained from alcohol licensure ($16.2 million in 2011).

The amount of revenue generated by legitimizing marijuana-related occupations (growers, trimmers, retailers, plant and seed sales) could prove to be more than direct taxes levied on marijuana itself. Assuming that 15% of the market's gross revenue is recouped through personal income taxes, Oregon could expect to see between $35 million and $98 million in additional income tax revenue each year. Combined with the above estimates of direct taxation on marijuana sales, the state could likely expect to earn between $72 million and $308 million by legalizing marijuana. Though this sounds impressive, particularly in the midst of crushing cuts to state programs from reduced revenues, these additions only amount to 1.4% and 6.4%, respectively, of the current $4.8 billion in revenue collected by Oregon. Additional savings could be derived from the criminal justice system; a thorough calculation is outside the scope of this study, but Miron (2005) estimates that enforcement and incarceration savings are likely to be double that of tax revenue generated from marijuana sales. If that were the case, marijuana legalization—in addition to providing a more logically coherent legal system and social integration for those participating in this particular black market activity—could prove to be a serious economic force in the state.

Finally, selecting the appropriate tax rate and licensing structure are the two most important policy considerations if the goal is to harmonize the existing informal marijuana market with its newly formalized counterpart—understanding the structure of the existing local market is critical. Researchers and policymakers often view illegal and legal markets as separate entities, but they in fact are part of a unified commodity production effort. In that regard, current participants in the informal market must have a mechanism to enter into the formal market if actor compliance is to occur; microbreweries, microdistilleries, and small vintners offer convincing parallels to draw from in that regard. Similarly, effective tax rates on any marijuana sold should be kept low in Oregon due to the existing average price ($177 per

ounce) in the informal market; expecting Oregon consumers to pay prices of $370 to $465 an ounce (Washington) or over $500 an ounce (Colorado) strains credulity. Oregon stands at a crossroads in regards to marijuana: with appropriate policy construction, it can harness the history and ecology of the State of Jefferson into a positive economic force. Contrarily, inappropriate policy construction will likely continue the trend of rising economic inequality and exploitation experienced by this internal periphery.

Conclusion

This study investigated the size and composition of Oregon's informal marijuana economy using webRDS and survey methods. The results suggest that average marijuana users consume approximately 6.75 ounces per year and pay approximately $177 per ounce. Most users purchase the drug from friends and nearly one third of all respondents indicate that they sell marijuana in small quantities. Growers tend to sell inauspicious quantities to friends and relatives and rarely earn more than $10,000 annually from their sales. Importantly, the composition of distribution networks suggests that the informal marijuana economy is a "robust network," particularly in states that allow personal medical production; the implications of this for lawmakers and law enforcers are profound in that it demonstrates that the 40-year-old "war on drugs" is not winnable using traditional law enforcement techniques. Several taxation schemes are presented to offer estimates of revenue if the drug were legalized in Oregon; these findings suggest that marijuana could contribute modestly to the state's total revenue (much more than alcohol).

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