

Six Years Later: Analyzing Online Black Markets Involved in Herbal Cannabis Drug Dealing in the United States

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Abstract

Cryptomarkets are online illicit marketplaces where drug dealers advertise the sale of illicit drugs. Anonymizing technologies such as the Tor network and virtual currencies are used to hide cryptomarket participants' identity and to limit the ability of law enforcement agencies to make arrests. In this paper, our aim is to describe how herbal cannabis dealers and buyers in the United States have adapted to the online sale of herbal cannabis through cryptomarkets. To achieve this goal, we evaluate the size and scope of the American herbal cannabis market on cryptomarkets and compare it to other drug markets from other countries, evaluate the impact of cryptomarkets on offline sales of herbal cannabis, and evaluate the ties between the now licit herbal cannabis markets in some States and cryptomarkets. Our results suggest that only a small fraction of herbal cannabis dealers and drug users have transitioned to cryptomarkets. This can be explained by the need for technical skills to buy and sell herbal cannabis online and by the need to have access to computers that are not accessible to all. The slow rate of adoption may also be explained by the higher price of herbal cannabis relative to street prices. If cryptomarkets were to be adopted by a larger portion of the herbal cannabis market actors, our results suggest that wholesale and regional distributors who are not active on cryptomarkets would be the most affected market's participants.

Keywords

darknet, cryptomarket, online illicit markets, herbal cannabis, United States

The sale of illicit drugs through electronic platforms called *cryptomarkets* started in 2011 and was put in the public eye through a Gawker media article about an “Underground Website Where You Can Buy Any Drug Imaginable” (Chen, 2011). Through cryptomarkets, drug dealers advertise their products

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and find customers (Aldridge & Décary-Héту, 2014). They use encrypted messages to negotiate the terms of their sales and receive the payments for their drugs, often in digital currencies, which are difficult to track for law enforcement. Given the physical nature of the products they sell, drug dealers must still also interface with the physical world to deliver their drugs, often using the regular mail and sealed packages (Martin, 2014a).

The online sale of illicit drugs provides many advantages over traditional physical sales (M. J. Barratt, Ferris, & Winstock, 2016). By moving transactions online in pseudo anonymous settings, cryptomarkets reduce the opportunities for physical contact and violence. Cryptomarkets also provide many conflict management strategies such as mediation by a trusted third party, the cryptomarket administrators (Morselli, Décary-Héту, Paquet-Clouston, & Aldridge, 2017). The technologies that make possible cryptomarkets are not the first technologies that have been adopted by offenders. They however beg the question as to whether they provide enough advantages to offenders that they will come to replace, eventually, the physical sale of illicit drugs.

The general aim of this paper builds on this question and describes how herbal cannabis dealers and buyers in the United States have adapted to online sales of herbal cannabis through cryptomarkets. More specifically, this paper evaluates the size and scope of the American herbal cannabis market on cryptomarkets compared to other drug markets from other countries. It also evaluates the impact of cryptomarkets on offline sales of herbal cannabis and finally describes the ties between the now licit physical herbal cannabis markets in some States and cryptomarkets. This study therefore limits its scope to the study of herbal cannabis in its herbal form, also known as marijuana, and excludes all other forms of herbal cannabis such as herbal cannabis resin (hashish) and oils.

The Structure of the Herbal Cannabis Market in the United States

The herbal cannabis market operates on two interconnected levels: the street (consumer) level and the upper (wholesale) level (Natarajan & Belanger, 1998). The street-level market is based on the herbal cannabis distribution between users and dealers while the upper-level market refers to the production and sale of large quantities of herbal cannabis, a process frequently controlled by criminal organizations. Street-level exchanges include all transactions between drug users and dealers no matter what physical location, technology, or communication equipment they use (Caulkins & Pacula, 2006; Curtis & Wendel, 2000; Natarajan, Zanella, & Yu, 2015). Many herbal cannabis users report receiving herbal cannabis as a gift, however, by growing it or by trading things with dealers (Caulkins, 2007; Caulkins & Pacula, 2006; United Nations Office on Drugs and Crime, 2006). This muddies the distinction between users and dealers in the street-level market, as most of the drug users give and/or sell herbal cannabis to friends or relatives.

At the upper (wholesale) level, actors are often embedded in criminal organizations that have multiple structures, from a collection of freelancers to hierarchical organizations (Natarajan et al., 2015). Freelance organizations are composed of small groups of individuals with no formal hierarchy and no clear division of labor. The relationships between members are unstable and vary over time. Hierarchical organizations are much more bureaucratic and have a clear division of labor. The position and role of actors in a hierarchical organization are mostly based on skills rather than based on family or friendship ties (Curtis & Wendel, 2000; Natarajan & Belanger, 1998). Criminal organizations operating at the upper level are active in wholesale and regional distribution of herbal cannabis but also, in some cases, in its production and importation. Wholesale distributors connect smugglers to regional distributors who deal with local suppliers of street-level drug dealers (Natarajan et al., 2015). As herbal cannabis is increasingly produced in the United States, more and more organizations that grow herbal cannabis can sell directly to wholesale distributors, bypassing the need for smugglers. The results from Natarajan, Zanella, and Yu's (2015) research show that many criminal organizations involved in herbal cannabis trafficking have more than a single role. Organizations in the herbal

cannabis upper-level market commonly smuggle drugs as well as distribute it at the wholesale and regional level. Growing herbal cannabis appears to be much less common. Of those that specialize, a majority appear to be smugglers or, in fewer instances, wholesale distributors. Just as with the street-level herbal cannabis market, the herbal cannabis upper-level market seems to present a lack of distinct roles between actors.

The pricing structure of herbal cannabis in the United States is hard to estimate for several reasons. First, most government reports do not have enough data to make legitimate representative estimates (Institute for Defense Analyses, 2008; United Nations Office on Drugs and Crime, 2006). Second, the lack of purity data for herbal cannabis limits the comparison between estimates of price per weight. Third, it is likely that there are differences between the prices paid by undercover agents and the price paid by established herbal cannabis market participants who use their social connection to get discounts (Caulkins, 2007). Finally, herbal cannabis users tend to trade informally and share among friends and acquaintances (United Nations Office on Drugs and Crime, 2006). Indeed, per the 2001 National Household Survey on Drug Abuse (Caulkins, 2007), 87% of herbal cannabis users acquired herbal cannabis from a friend or relative and 58% obtained it for free, demonstrating the reach of social supply and suggesting that it may be difficult to track such informal trading.

Still, the available data from United Nations Office on Drugs and Crime (2006) suggest that the United States is one of the most expensive countries to buy herbal cannabis in. Not all users and dealers pay the same price, with variables such as relationships between buyers and sellers, the quantity purchased, the frequency of purchase, and the transaction's location all influencing the price per gram paid. Articles on herbal cannabis divide the amount purchased in multiple ways, from top-level retail to lower-level retail (Wilkins & Sweetsur, 2006). Some divide these levels into four categories to better understand the economy of scale and the impact of making wholesale purchases (Caulkins & Pacula, 2006; Institute for Defense Analyses, 2008; Office of National Drug Control Policy, 2012). Under 5 g, herbal cannabis is priced at around US\$7.84 per gram. Between 5 and 10 g, the unit price decreases to less than US\$5, with an average price of US\$4.68 per gram. It is estimated that about two thirds of herbal cannabis transactions are for amounts of 10 g and less (Caulkins & Pacula, 2006; Office of National Drug Control Policy, 2012). These two categories reflect the retail level and are exploited by drug users and social suppliers. Actors who resell herbal cannabis or buy wholesale pay much less for herbal cannabis. Between 10 and 28 g, buyers pay on average US\$3.84 per gram for a total purchase of less than US\$100. About 25% of all herbal cannabis transactions appear to be in this range (Caulkins & Pacula, 2006; Office of National Drug Control Policy, 2012). Between an ounce (28 g) and a pound (454 g) of herbal cannabis, buyers pay between US\$1.79 and US\$2.50 per gram, a steep discount compared to the retail price (Caulkins & Pacula, 2006; Institute for Defense Analyses, 2008; Office of National Drug Control Policy, 2012). Transactions over a pound represent less than 1% of all herbal cannabis purchases. Smugglers, wholesale, and regional distributors usually make purchases at that level with about half of them purchasing 1 or 2 pounds and a third of them buying more than 5 pounds (Caulkins & Pacula, 2006). The price paid at this level is on average US\$0.49 per gram. These prices were collected in two data sets from the early 2000s and may differ from current herbal cannabis prices. There is unfortunately no literature that has measured the trends in these specific prices, and it is therefore impossible at this point to provide a better reference point for our analyses.

The Rise of Cryptomarkets

The structure of the herbal cannabis markets is by now well understood and studied. The ability of their participants to adapt over the years, among other illicit drug market participants, has been analyzed in detail (Bouchard, 2007). A key factor that impacted drug markets was the development of new technologies such as mobile phones and pagers (Natarajan, Clarke, & Johnson, 1995). These devices were adopted en masse by drug dealers who no longer needed to be in a specific physical location to

conduct transactions; customers could reach them anywhere and arrange to meet at a discreet location. This led to the shift from open-air markets to closed markets (May & Hough, 2004).

Mobile technologies are not the only technology that have impacted drug dealing. The evolution of virtual currencies, encrypted communications, and anonymous Internet connections all played a role in the development of a technical innovation that has attracted much attention over the past 6 years, the *cryptomarkets*. Cryptomarkets are anonymous illicit online marketplaces that share many of the visual cues with popular online merchant websites like Amazon and eBay (Martin, 2014). Vendors who are approved by the platform administrators set up vendor profiles and listing pages for each of the products or services they wish to sell. These include illicit drugs, stolen financial information, stolen identity papers, and computer viruses as well as licit products such as burner phones, computers, scales, and e-books (Kruithof et al., 2016). Vendor profiles and listings are important for the creation of bonds of trust between buyers and vendors (Tzanetakis, Kamphausen, Wersé, & von Laufenberg, 2016). Cryptomarkets provide vendors with a relatively safe setting from which to operate. The identity of cryptomarket participants is protected by anonymized connections that hide their IP address, the information commonly used to trace online activities. This reduces many of the risks associated with drug dealing such as the risk of arrest or the risk of violence (Van Hout & Bingham, 2014). Cryptomarkets also provide vendors with a large pool of potential customers who can be located anywhere in the world given that all purchases are hidden in shipped packages usually sent through mail. Because of inspections at international borders, it seems that more and more buyers are opting to purchase from domestic vendors, meaning vendors in the same country as them, or at the very least, in the same general geographic region as them (Demant, Aldridge, Décary-Héту, & Munksgaard, 2018). Vendors willing to take on the risk to sell internationally appear to do so for smaller packages, when they are reputable vendors with high visibility, and when they are themselves in countries where law enforcement is more limited, less effective, and where the general population has lower revenues (Décary-Héту, Paquet-Clouston, & Aldridge, 2016).

This new way to deal with drugs shifted the skills needed to become a dealer, making it essential to have good people skills and innovative marketing strategies such as Halloween or Christmas discount specials (Martin, 2014). Cryptomarkets finally provide vendors with the ability to advertise their products either in listings or in discussion forums associated to cryptomarkets. Professional photos of drugs are used to draw in customers and attest the quality of the products offered (Van Hout & Bingham, 2014).

Customers can browse the vendors' listings using the cryptomarkets' category trees or search for specific products (e.g., *cocaine* for sale by *American dealers*). To select which vendor to buy from, customers can look at the feedbacks posted by past buyers. All feedbacks are aggregated at the vendor level just as is the case on Amazon or eBay. Cryptomarket customers appreciate the safety that cryptomarkets provide. The feedback mechanism reduces the risks of being cheated on during a transaction and the anonymity of cryptomarkets increases the sense of safety of customers (Van Hout & Bingham, 2013a). Drugs are believed to be of higher quality on cryptomarkets, especially since vendors of impure drugs should be quickly identified using the feedback systems. Some have suggested that this could reduce the potential harm associated with drug use (Maddox, Barratt, Allen, & Lenton, 2016), especially since

Silk Road is a paradise for responsible drug dealers. I mean it's not the type of site where you can show up at your dealer's house banging on their door because you need your fix this instant. You have to be patient and you have to be smart. (Buxton & Bingham, 2015, p. 12)

Cryptomarkets are home to a community where illicit drug consumption is not considered as wrong or immoral. This libertarian philosophical framework seems to be an important reason for participants who have joined the cryptomarkets' community (Maddox et al., 2016).

The first cryptomarket, Silk Road (SR1), was launched in 2011 and remained active for 2½ years before being shut down by the Federal Bureau of Investigation in late 2013. At its height, it generated revenues of about US\$90 million on a yearly basis (Aldridge & Décary-Héту, 2014) and had hundreds of thousands of accounts. In the years since, dozens of cryptomarkets have been launched. None managed to create a monopoly like SR1, and online drug sales are now distributed across perhaps five or so large cryptomarkets. Combined, they generate around 200 million US dollars in yearly revenues (Kruithof et al., 2016; Soska & Christin, 2015), and herbal cannabis represents about a quarter of all sales (Soska & Christin, 2015). Many police operations have targeted cryptomarkets in recent years (see, e.g., Décary-Héту & Giommoni, 2017). Past research found that police operations had an impact on the volume of sales for a short period of time following a police operation (Soska & Christin, 2015) but that cryptomarket activity quickly bounced back in the months following the police operations (Décary-Héту & Giommoni, 2017). Cryptomarkets represent a shift back to open markets as the anonymity they provide allows for dealers to safely transact with unknown customers. Dubbed open anonymous markets (Aldridge & Décary-Héту, 2017), cryptomarkets represent an important innovation in the way drugs are bought and sold.

The Size and Scope of the Herbal Cannabis Market in the United States

In the general population aged 12 and above in the United States, herbal cannabis use is common (Substance Abuse and Mental Health Services Administration, 2014, 2015), with over 20 million American herbal cannabis users. While illegal at the federal level, herbal cannabis possession and sale has been legalized for medicinal and recreational purposes in several states of the United States. Law enforcement agencies have refrained so far from targeting the herbal cannabis users and dealers that respect state legislations. The users must smoke in a private setting, and the distinctive smell of herbal cannabis must not be detected in public areas. Individuals can grow a few plants at home, though it is illegal to do so in Washington. Herbal cannabis is most commonly purchased in small quantities at a time in licensed stores.

To measure the size and scope of the herbal cannabis market, researchers have studied both the supply side and the demand side of herbal cannabis as well as data on seizures and plant destruction ratios. On the supply side, researchers have calculated the number of ounces of herbal cannabis a plant can produce and then multiplied that by the number of plants grown (Bouchard, 2008). The supply side estimates can also focus on the dealers' earnings or sales, a method often used to study cryptomarkets (Demant, Munksgaard, & Houborg, 2016). The demand side of herbal cannabis is also commonly estimated, as it is often easier to reach drug users than drug dealers. Many researchers have used surveys to quantify the number of consumers (Hakkarainen, Kainulainen, & Perälä, 2008; Wilkins, Reilly, Pledger, & Casswell, 2005). Many countries conduct surveys that target its population's drug using habits, and many articles are based on these governmental statistics (Kilmer & Pacula, 2009).

Herbal cannabis production is spread around the world. Between 1994 and 2004, herbal cannabis production estimates were generated for a total of 176 countries and territories. In comparison, only six countries provided coca leaf production estimates over the same period (United Nations Office on Drugs and Crime, 2006). Morocco, Afghanistan, Mexico, and Paraguay are important sources of herbal cannabis; Interpol also lists South Africa, Nigeria, Pakistan, Colombia, and Jamaica as important source countries for herbal cannabis (Reuter & Greenfield, 2001). In the United States, 76% of the imported herbal cannabis comes from neighboring countries, Mexico (56%) and Canada (20%). Seizures at the borders were much more common at the Mexican border in 2008 where 1,253 metric tons of herbal cannabis were seized compared to 3 metric tons coming from Canada (U.S. Department of Justice, National Drug Intelligence Center, 2010). Herbal cannabis can be cultivated both indoors and outdoors, sometimes by the drug users themselves. The United States domestic production is believed to be on the rise over the last decade. In 2013, the United States eradicated 6,376 outdoor and

2,747 indoor sites, resulting in the destruction of over 4.4 million herbal cannabis plants (United Nations Office on Drugs and Crime, 2015; U.S. Department of Justice, Drug Enforcement Administration, 2014). Herbal cannabis cultivation is particularly widespread in the states of California, Kentucky, Tennessee, Hawaii, Washington, Florida, and New Hampshire (Canada and United States of America, 2008).

The American Herbal Cannabis Market on Cryptomarkets

Van Buskirk, Naicker, Roxburgh, Bruno, and Burns's (2016) study of cryptomarkets focused on the country of origin of specific drugs. The countries providing the most listing of drugs were the United States, the United Kingdom, Australia, China, and the Netherlands. Van Buskirk et al. suggested that the biggest share of listings came from the United States, and herbal cannabis was the most popular drug in the American listings. The herbal cannabis listing represented more than 44% of the drugs listed originating from the United States. Van Buskirk et al.'s paper was limited, however, as it only focused on one marketplace called *Agora*, where the size and scope of the American herbal cannabis drug market could not be representative of that of other marketplaces. Moreover, it identifies vendors using only the pseudonym of the vendors published on the listing pages. No effort is made to identify vendors who use multiple pseudonyms or to connect vendor accounts across cryptomarkets. Using more than one identification method may be more accurate. Building on this research, *the general aim of this paper is to describe how herbal cannabis dealers and buyers in the United States have adapted to online sales of herbal cannabis through cryptomarkets*. Our first specific aim will be to *evaluate the size and scope of the American herbal cannabis market on cryptomarkets compared to other drug markets from other countries*. Given the prevalence of herbal cannabis use in the United States, we expect to find that the herbal cannabis market will take up a large proportion of all sales from American cryptomarket vendors. Our second specific aim will be to *evaluate the impact of cryptomarkets on offline sales of herbal cannabis*. Most sales of herbal cannabis are made to drug users who pay between US\$5 and US\$10 per gram. We expect to find that much of the transactions facilitated by cryptomarkets will be in this range, though we may find wholesalers and regional distributors looking to source their stock online or expand their distribution channels. Finally, our third specific aim is to *evaluate the ties between the now licit herbal cannabis markets in some States and cryptomarkets*. Cryptomarkets could be used to sell herbal cannabis produced in states where herbal cannabis has been legalized, providing an environment that may be less inclined to monitor and enforce laws that regulate the production and sale of herbal cannabis. As no study has looked at the impact of herbal cannabis legalization on online sales, this paper will provide an exploratory look into the ties between licit and illicit drug sales.

Data and Method

The data for this paper were collected in January 2016 using the DATACRYPTO software tool (Décarry-Héту & Aldridge, 2013). This tool acts in a similar way to Google indexing robots and downloads all the webpages hosted on any given website. It then extracts, from each page, the relevant information (e.g., product title, price, description). DATACRYPTO was used to monitor eight cryptomarkets. These cryptomarkets were selected, as they were the eight largest cryptomarkets in activity at the time and therefore represented the vast majority of online listings at the time.

Online data collection on cryptomarkets has been problematic in the past (Munksgaard, Demant, & Branwen, 2016). DATACRYPTO data have however been used in many leading peer-reviewed publications (see, e.g., Décarry-Héту et al., 2016; Martin, Cunliffe, Décarry-Héту, & Aldridge, 2018). Examination of DATACRYPTO has also led Demant, Aldridge, Décarry-Héту, and Munksgaard

Table 1. Descriptive Statistics of Cryptomarkets.

Cryptomarket	Number of Products	Number of Vendors ^a
Alphabay	37,896	2,001
Cryptomarket	8,362	432
Dark net heroes league	387	76
Dreammarket	22,284	847
French dark net	1,307	331
Hansa	4,829	219
Nucleus	26,538	1,013
Python	4,208	144
Total	105,811	5,063

^aVendors who operated on multiple cryptomarkets were included in the count of vendors for each cryptomarket where they operated. The total number of vendors is therefore not indicative of the unique number of vendors active on cryptomarkets in January 2016.

(2018) to support the quality and reliability of DATACRYPTO data. Table 1 presents the descriptive statistics of the data collected on each cryptomarket.

Overall, 105,811 product pages were downloaded. These products were offered by 3,846 vendors. As many vendors commonly have accounts on more than one cryptomarket (Broséus et al., 2016), we matched vendors based on the encryption key they asked their customers to use. Messages encrypted using this key can only be decrypted using the associated decryption key that remains private always. Vendor accounts that post the same encryption key must therefore belong to the same drug dealer. Vendor accounts were, furthermore, matched by comparing the description vendors provide. Two accounts with the same name and description on two different cryptomarkets were believed to belong to the same drug dealer.

To evaluate the size and scope of the American cryptomarket herbal cannabis market, we analyzed the number of products and the revenues generated by products that were being listed as “shipping from the United States.” Cryptomarket vendors usually list the country they operate from to attract domestic customers. International customers may be willing to pay more for a product, but searches of packages are common at national borders and increase the risk of seizures. Vendors therefore have a strong incentive to be honest about where they ship from. To calculate the revenues generated by each product, we counted the number of feedbacks posted on a product page in the last 30 days and multiplied that number by the price of the product. In the case of products that had not been active for 30 days, we extrapolated the number of feedbacks based on the life span of the product, meaning that a product that had received five feedbacks over the past 15 days was considered to have 10 feedbacks in our analyses ($30/15 \times 5$). Using feedbacks is a proven method to estimate revenues generated on cryptomarkets (Décary-Héту et al., 2016; Soska & Christin, 2015), and Kruithof et al. (2016) found that about 70% of transactions led to a feedback. Descriptive statistics on the number of vendors operating from the United States will be presented.

The quantity of herbal cannabis sold in each product page was manually extracted from the listings. Five coders were supervised by the first author to do so. Coders did not code the same listings but were all asked, at the end of the coding phase, to code a sample of 200 listings selected at random to measure their inter-rater agreement. Based on intraclass correlation using a two-way mixed model, their inter-rater agreement stands at 100% for quantity. Descriptive statistics are presented for the number of products in five weight categories: 5 g and under, 5–10 g, 10–28 g (an ounce), 28–454 g (a pound), and more than a pound.

Finally, a qualitative analysis of the product and vendor descriptions will be presented. These analyses sought to identify products or vendors who were tied to one of the five states where herbal

Table 2. Distribution of All Sales Across Product Categories.

Product Categories	N	%	Revenues From Last Month	%
Prescription	14,511	14	US\$2,185,147	14
Herbal cannabis	10,190	10	US\$3,150,692	21
Ecstasy	9,972	9	US\$2,262,850	15
Other drugs	9,791	9	US\$1,453,045	10
Stimulants	7,852	7	US\$3,461,023	23
Psychedelics	6,622	6	US\$1,020,059	7
Opioids	1,979	2	US\$751,021	5
Alcohol + tobacco	70	0	US\$2,683	0
Subtotal	60,987	58	US\$14,286,521	95
Non-drug related products	44,824	42	US\$817,580	5
Total	105,811	100	US\$15,104,101	100

cannabis has been legalized in the United States at the time of data collection: Alaska, Colorado, District of Columbia, Washington, and Oregon. The names and abbreviations of these states were queried in the listings' titles and products to identify products and vendors who blended between the licit and illicit herbal cannabis markets. Our analyses found 91 listings that mentioned Colorado, 13 that mentioned Alaska, and 1 that mentioned Washington. We will describe the mentions of how legal infrastructures were being used to participate in the illicit herbal cannabis market, either as a source of drugs or to improve the image of the drugs for sale.

Herbal Cannabis Listings From Vendors Operating in the United States

Cryptomarkets facilitate transactions of a wide array of products from e-books to weapons. Table 2 presents the distribution of sales across the different product categories offered on cryptomarkets. Table 2 presents data from all vendors, not just the American vendors.

Cryptomarkets have become quite diversified, making available both drug-related (58% of listings) and non-drug-related products (42% of listings). In the drug categories, cannabis is the second most common type of drugs offered with 17% of all listings after prescription drugs (14%) but before ecstasy (9%). In the non-drug-related products, e-books are the most popular category with 21% of listings. Other fraud products and services and counterfeit products represent 7% and 5% of listings, respectively. While important, the number of products is not the best indicator of cryptomarket activity. Indeed, any vendor can put up hundreds of listings that generate no sales. Revenues represent a much better representation of the activities on cryptomarkets. Herbal cannabis represents 21% of all sales generated on cryptomarkets for a total of US\$3.1 million per month. This is very close to the revenues generated by prescription drugs that account for 21% of all revenues, and almost 4 times all of the non-drug-related categories combined. Cryptomarkets therefore appear to be heavily invested in the sale of cannabis. Cryptomarkets are international platforms with vendors operating from dozens of countries. Table 3 presents the distribution of products and revenues across the country of operation of vendors and further investigates the distribution of products and herbal cannabis in different countries.

The country of operation of vendors is either unknown or listed as a region (e.g., Europe, North America) in almost half of the listings (46%). When a country of operation is advertised, two countries stand out: the US with 17% of all products and the UK with 10% of all listings. These two countries make up the majority of revenues (51%). Australia, Germany, Netherlands, and Canada make up the next 32% of revenues. Customers appear to be reluctant to make purchases from vendors operating in unknown countries or vague regions as their products only generated 11% of all sales. The US and the UK are also major players in the cryptomarket trade of herbal cannabis. The US accounts for 35% of

Table 3. Distribution of Listings and Revenues for All Listings and Herbal Cannabis Listings Across the Country of Operation of Vendors.

Product Categories	All Listings				Herbal Cannabis Listings			
	N	%	US\$ (M)	%	N	%	US\$ (M)	%
US	18,271	17	US\$5.26	35	3,615	35	US\$1.58	50
UK	10,663	10	US\$2.41	16	1,654	16	US\$0.27	9
Netherlands	6,663	6	US\$1.12	7	660	6	US\$0.08	3
Germany	5,221	5	US\$1.19	8	853	8	US\$0.31	10
Australia	3,314	3	US\$1.55	10	406	4	US\$0.23	7
Canada	2,985	3	US\$1.02	7	768	8	US\$0.28	9
China	2,934	3	US\$0.08	1	0	0	US\$0.00	0
France	896	1	US\$0.24	2	128	1	US\$0.04	1
Spain	272	0	US\$0.14	1	96	1	US\$0.08	3
Afghanistan	512	0	US\$0.08	1	1	0	US\$0.00	0
Other countries	5,968	6	US\$0.36	2	411	4	US\$0.05	2
Multiple countries	31,698	30	US\$1.47	10	1,336	13	US\$0.22	7
Unknown countries	16,414	16	US\$0.17	1	262	3	US\$0.01	0
Total	105,811	100	US\$15.10	100	10,190	100	US\$3.15	100

Note. All dollar amounts in millions of U.S. dollars.

Table 4. Distribution of Vendors on Cryptomarkets.

Total number of vendors	3,846
Vendors who operate from the US	1,060
Vendors who sell herbal cannabis	853
Vendors who operate from the US and sell herbal cannabis	259

herbal cannabis listings and 50% of the revenues they generate. Germany, the UK, Australia, and Canada are the next most important sources of cryptomarket herbal cannabis, with revenues ranging from 7% to 10%. These numbers highlight once again the need to look at revenues to identify the true relevance of vendors in cryptomarkets.

These aggregate revenue numbers provide some insight into the role of the United States in the sale of herbal cannabis on cryptomarkets. Table 4 further highlights the importance of the United States by comparing the number of vendors and herbal cannabis vendors from the United States versus the rest of the world. We identified 3,846 vendors in our data set and from those, about 28% operated from the United States. Some of them were offering products from other countries, but at least one of their listings was coming from the United States. This is by far the largest contingent of vendors from any country. Herbal cannabis sale is very important for the American vendors as 24% of them offered at least one listing in the herbal cannabis category. These vendors may be selling other drugs as well, but this indicates the importance once again of herbal cannabis sales for vendors. About 7% ($N = 259$) of all vendors operated from the United States and sold herbal cannabis.

Table 5 presents the distribution of listings, transactions, and revenues generated by the herbal cannabis products of American vendors.

Vendors who operated from the United States posted between 1 and 249 listings of herbal cannabis on cryptomarkets. Half of the vendors had six or fewer listings; half of them also had between 2 and 14 listings. Overall, 3,615 herbal cannabis listings were offered by vendors who operated in the United States. Transactions appeared to be distributed as unevenly as the number of products with vendors making 0–1,064 transactions per month. Half of the vendors made 4 transactions per month for a total of

Table 5. Distribution of Listings, Transactions, and Revenue Generated by the Herbal Cannabis Products of American Vendors.

Product Categories	Minimum	Maximum	Median	IQR	Total
Number of listings	1	249	6	2–14	3,615
Number of transactions	0	1,064	4	0–27	6,625
Revenues generated over past 30 days	US\$0	US\$205,406	US\$253	US\$0–US\$3,800	US\$1,576,265

Note. IQR = Interquartile range.

Table 6. Distribution of Weights of Herbal Cannabis Offered by American Vendors on Cryptomarkets.

Product Categories	Number of Listings	Past Month Transactions	Past Month Revenues (US\$)	Avg Price per Gram (US\$)
5 g and under	744	1,192	39,105	24.56
Between 5 and 10 g	617	1,552	117,424	11.88
Between 10 and 28 g	1,129	2,455	439,645	8.99
Between 28 and 454 g	969	1,249	898,237	5.73
Over 454 g	56	11	37,818	4.72
Unknown weight	100	167	44,036	
Total	3,615	6,625	1,576,265	

6,625 transactions of herbal cannabis by American vendors. Seventy-five percent of vendors made 27 or fewer transactions per month. This explains the wide differences in revenues of vendors. The most successful vendor made over US\$200,000 in a single month, while the median revenues of vendors stood at US\$254. This figure does not represent an important income in absolute terms, but vendors may be able to generate more income through the sale of other types of products or offline licit/illicit work.

American vendors have listings for a wide range of weight. Some should therefore be considered in the same class as street dealers, while others could be classified as either regional or even wholesale distributors. Table 6 presents the distribution of weights of herbal cannabis offered by American vendors on cryptomarkets.

Most listings posted by American herbal cannabis dealers are in the 10–454 g range ($N = 2,098$). Hundreds of listings were also available in the other weight categories except for the largest category, over 454 g, where only 56 listings were available. Over a third of the transactions occurred at the 10–28 g level ($N = 2,455$). Transactions were distributed relatively evenly among the other levels except, once again, for the listings over a pound where only 11 transactions were registered over the past month. The distribution of revenues shows a somewhat different distribution with much of the revenues (57%) generated by listings in the 28–454 g level. The second most important level is the 10–28 g; all other categories generated much lower sales ranging from US\$37,818 to US\$117,424. Revenues generated at the very highest level only generated US\$37,818. The price per gram of herbal cannabis appears to decrease as the amount of herbal cannabis sold increases. Purchases made for small quantities of herbal cannabis (5 g and under) cost on average US\$24.56 per gram. The price of herbal cannabis for purchases made at the pound or even higher-level drops to US\$4.72, only 19% of the price of herbal cannabis at the 5 g and under level.

Connecting the Legal and Illegal Herbal Cannabis Markets

Our qualitative analyses saw evidence of a connection between cryptomarkets and the herbal cannabis markets (licit or illicit) in states where recreational herbal cannabis has been legalized. One hundred five listings were found when searching our database for herbal cannabis listings with descriptions or

titles with a reference to a state where recreational herbal cannabis is legalized. Ninety-two listings referenced Colorado, 12 Alaska, and 1 Washington.

The name or abbreviation of the states was used in many cases to provide background on the herbal cannabis strain for sale. This is the case, for example, of the Matanuska Tundra strain from Alaska. In most cases, there was no indication about the connection between the vendor and licit or illicit herbal cannabis markets in specific states. Some mentioned that the herbal cannabis was grown in the state of Colorado, for example, but did not say whether the grower was a licensed grower or not. Some clues suggested the vendors could be operating from Colorado as they mentioned they worked in Mountain Time Zone, but no further information was available. Other vendors use the legal herbal cannabis distribution system as a reference point. Vendors used terms like “dispensary grade” herbal cannabis to indicate that their herbal cannabis was of very high quality. These vendors also compared the price per gram of their listings to the official price of legal herbal cannabis. Their aim here appeared to be to demonstrate that they could provide a similar product at a discount for customers.

A more interesting case scenario was when vendors openly mentioned their connection to the licit herbal cannabis market. In one case, a vendor offered to buy herbal cannabis from a legal herbal cannabis store in Seattle and then ship the drugs by mail. In order to prove that customers were legally allowed to purchase herbal cannabis in the state, the customers were asked to walk into a herbal cannabis store, take a picture of the products they needed, walk out without purchasing the drug, and attach the screenshot to their cryptomarket order. The seller would then have gone and bought the product for the consumers. This instruction may be simply a smoke screen to somewhat legitimize the vendors’ activities as a few lines below in the description, the vendor stated that he was offering a reseller service for customers who lived in states where herbal cannabis was not legal. The vendor clearly stated that he was not affiliated in any way with the specific store mentioned in the listing description. Another vendor also stated that he purchased his herbal cannabis from legal stores and that he needed to have a reasonable number of orders before he would go into the stores to make the purchases. This specific vendor also sold prescription drugs. This is interesting since it provides information on the vendors, buying legally sold herbal cannabis and selling it online might reflect a more opportunistic criminal and not a regular herbal cannabis seller or more professional wholesale vendor.

Discussion and Conclusion

The general aim of this paper was to describe how herbal cannabis dealers and buyers in the United States have adapted to online sales of herbal cannabis through cryptomarkets. Based on past research, it appears that only a small fraction of herbal cannabis dealers and drug users have transitioned to cryptomarkets. Indeed, the total yearly revenues generated by American herbal cannabis cryptomarket vendors are evaluated at US\$38 million, far from the tens of billions of dollars exchanged in the traditional herbal cannabis market in the United States.

There are many obvious reasons as to why the American herbal cannabis sales on cryptomarkets have not grown more over the past 6 years. Selling and buying online requires some technical skills and access to computers that are not accessible to all. The Tor Browser and online training have made it much easier to connect to the Tor network and purchase Bitcoins, but there is still a high barrier to enter cryptomarkets for less computer-literate individuals. Furthermore, since herbal cannabis must be mailed, there are often a few days of delay between an order being placed and its delivery. Many customers may not be willing or able to wait so long for their drug.

Another explanation for the small herbal cannabis market cap of cryptomarkets is the relatively high price of herbal cannabis online. Past research has found that street prices for herbal cannabis were considerably lower and represented 10–43% of the price per gram paid on cryptomarkets. Indeed, drug users paid on average US\$7.84 per gram when purchasing 5 g or less of herbal cannabis (Caulkins &

Pacula, 2006; Office of National Drug Control Policy, 2012); cryptomarket customers paid on average US\$24.56, more than 3 times this amount. This makes cryptomarkets an expensive alternative that could arguably offer more security but at a cost to customers. This is especially true since these cryptomarket prices do not always include the costs of shipping. The risk and price theory (Reuter & Kleinman, 1986) suggests that drug prices increase because of the risks associated with law enforcement (Van Hout & Binham, 2014). Drug dealers take into account the periods of incarceration and the losses due to police seizure when they set their price. Prices on cryptomarkets therefore suggest that the risks of selling online are either much higher than those of selling offline or that the vendors have not been able to measure the actual risks of dealing online and have not priced their drugs accordingly. Vendors would in this scenario not be taking any chance in this unproven setting and would add on more costs to cover any risk they face. If this is the case, we should expect cryptomarket prices to move over time to an equilibrium state where they will reflect the true risks of dealing on cryptomarkets. Future research should look into the trends in herbal cannabis prices to determine whether and when that equilibrium is reached. Another explanation is that rather than imposing a tax for risks, vendors may be imposing a tax for security and convenience. Cryptomarket customers can make purchases directly from their home and only a few arrests have been reported so far. This could lead the herbal cannabis dealers to believe that there are fewer risks when buying drugs online and that this benefit should be compensated by higher prices. In this scenario, vendors would not be taking into consideration that the risks of arrest for any transaction is higher for buyers than vendors as it is the buyer's name and address that ends up on the package containing the drugs. Tracing back the source of that package is much difficult.

If cryptomarket-facilitated sales were to continue to grow, wholesale and regional distributors who are not active on cryptomarkets would be the most affected market's participants. Over half of all revenues generated for herbal cannabis on cryptomarkets were for transactions of 28–454 g, typical transactions for wholesale and regional distributors. Cryptomarkets could become an alternative distribution channel that would reduce the potential sales of distributors who refuse to go online. Our results suggest that drug users looking to source their own supply or to socially supply as well as local suppliers and low-level drug dealers likely represent an important share of all cryptomarket customers. While not uncommon, small purchases (under 5 g) generate very small revenues and are therefore unlikely to attract a large portion of vendors. Transactions between an ounce and a pound offer the highest revenues per transaction on average, making it the most attractive portion of the market to be in. Given the typical profile of customers, many layers of the herbal cannabis market are likely to be involved in cryptomarkets in the longer term.

The results shown in this paper add to the literature on herbal cannabis and follows Van Buskirk et al.'s (2016) results showing that most listing from the cryptomarkets are from the United States, and herbal cannabis is one of the most prevalent drug. However, when studying all drug listings, the top five countries for Van Buskirk et al. (2016) were the United States, the United Kingdom, Australia, China, and the Netherlands, but when the focus is only on herbal cannabis, the top five countries are the United States, Germany, the United Kingdom, Canada, and Australia. These results are also consistent with the demand since North America, Western Europe, and Oceania have higher herbal cannabis consumption rate (UNODC, 2009). In this sense, herbal cannabis listings are more abundant where the demand is higher.

There is very little evidence so far that cryptomarkets are connected to the licit herbal cannabis market in the United States. Indeed, we only found two vendors who explicitly said that they sourced their stock from licensed stores in Colorado. This is not entirely surprising since these stores limit the amount of herbal cannabis a customer can purchase each visit. Legally buying large amounts of herbal cannabis would be time-consuming and possibly expensive. More vendors did state that herbal cannabis was either grown in a state where recreational herbal cannabis is legalized or at least sold strains that come from these states. This warrants further investigation into the connection of the licit and

illicit herbal cannabis markets as legal infrastructures could be used as a front for larger, unregulated, and untaxed illicit activities. Interestingly, the first cryptomarket was launched in part as a reaction to capitalist markets that price gouge customers and to constant monitoring by governments and large companies. Cryptomarkets were therefore meant to be settings where individuals could sell and buy any product, be it legal or illegal, without any intervention by outside actors. We already see a wide array of legal (or supposedly legal in the case of counterfeit) products being offered on cryptomarkets including books, jewelry, clothing, accessories, and more. It would be a logical evolution for legalized herbal cannabis sales to move to the Internet, with a share going to cryptomarkets because of their established reputation for dealing in this drug.

Conclusion

While cryptomarkets have not managed to control a sizable portion of the herbal cannabis trade in the United States, their size has increased over the past 6 years. Revenues appear to have doubled between 2013 and 2015 in cryptomarkets in general, demonstrating the growing interest of market participants for cryptomarkets. This study described the current size and scope of the American herbal cannabis market on cryptomarkets and sought to understand how drug users and dealers would likely adapt to this new distribution channel over the coming years. Given the illicit nature of the herbal cannabis market, it is still difficult to rigorously estimate its size and scope. Cryptomarkets provide a new setting from which reliable information can be gathered regarding the price per gram, the number of transactions, and the number of participants involved in it. This will likely provide valuable intelligence for law enforcement agencies but even more so for public health officials. Indeed, cryptomarkets will provide us with indications as to what drug is used in what quantity and where. Our results showed that a majority of sales were made by vendors who disclosed their country of operation. Demant et al. (2018) also strongly suggest that sales are moving more toward domestic or regional sales. As such, cryptomarket data should provide us with at least general trends in what drugs are most commonly used in which countries. Of course, this information would never truly represent the larger illicit drug markets but could give indications on the illicit drug market trends. Automated monitoring systems could be set up with relatively low efforts to generate reports on drug purchases and detect shifts in the use of drugs in the United States and other countries. Our results were limited in that it was difficult to compare the cryptomarket herbal cannabis market, a known entity, to the traditional herbal cannabis market for which very little is known. Drug prices in the streets vary so much depending on the quantity purchased, the quality of the drug, and personal ties that comparing cryptomarket prices to these can be difficult at times. A last limit relates to the hidden sales on cryptomarkets (Christin, 2013). Vendors and buyers can indeed message each other to arrange private sales, a practice most common for large quantities. As such, it is possible that our results underestimate larger sales of herbal cannabis, though no past research has been able to measure exactly how important these private sales could be. Future research should seek to gain access to seized cryptomarket servers to investigate this important question. We believe, however, that cryptomarkets represent a valuable source of data on drug markets, and they should be invested by researchers moving forward.

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