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Research paper

Hidden wholesale: The drug diffusing capacity of online drug cryptomarkets

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ABSTRACT

Background: In spite of globalizing processes 'offline' retail drug markets remain localized and – in recent decades – typically 'closed', in which dealers sell primarily to known customers. We characterize drug cryptomarkets as 'anonymous open' marketplaces that allow the diffusion of drugs across locales. Where cryptomarket customers make stock-sourcing purchases for offline distribution, the cryptomarket may indirectly serve drug users who are not themselves cryptomarket customers, thereby increasing the drug diffusing capacity of these marketplaces. Our research aimed to identify wholesale activity on the first major cryptomarket, Silk Road 1.

Methods: Data were collected 13–15 September 2013. A bespoke web crawler downloaded content from the first major drug cryptomarket, Silk Road 1. This generated data on 1031 vendors and 10,927 drug listings. We estimated monthly revenues to ascertain the relative importance of wholesale priced listings.

Results: Wholesale-level revenue generation (sales for listings priced over USD $1000.00) accounted for about a quarter of the revenue generation on SR1 overall. Ecstasy-type drugs dominated wholesale activity on this marketplace, but we also identified substantial wholesale transactions for benzodiazepines and prescription stimulants. Less important, but still generating wholesale revenue, were cocaine, methamphetamine and heroin. Although vendors on the marketplace were located in 41 countries, wholesale activity was confined to only a quarter of these, with China, the Netherlands, Canada and Belgium prominent.

Conclusions: The cryptomarket may function in part as a virtual broker, linking wholesalers with offline retail-level distributors. For drugs like ecstasy, these marketplaces may link vendors in producer countries directly with retail level suppliers. Wholesale activity on cryptomarkets may serve to increase the diffusion of new drugs – and wider range of drugs – in offline drug markets, thereby indirectly serving drug users who are not cryptomarket customers themselves. Cryptomarkets provide researchers and policy makers with a rich source of drug monitoring information. Further research should ascertain whether their virtual location may reduce the violence associated with middle market drug activity. We caution that conflict may instead manifest in other ways, including threats, fraud, and blackmail.

Introduction

A cryptomarket is an online marketplace platform bringing together multiple vendors listing mostly illegal goods and services for sale. Predominant on these markets is the sale of illegal and illicit drugs (Aldridge & Décary-Hétu, 2014; Barratt, Ferris, & Winstock, 2014; Christin, 2013; Martin, 2013; Van Hout & Bingham, 2014).[1] Cryptomarkets share the same look and feel of 'clear web' marketplaces like eBay and Amazon by allowing their customers to search and compare products and vendors. What differentiates these from established clear web marketplaces is their hidden aspect. Cryptomarkets employ from amongst a range of strategies to hide the identity of their participants and

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[1] For an exception, see Dolliver (2015a) although note criticism of her methodology (Aldridge and Décary-Hétu, 2015; Dolliver, 2015b; Munksgaard, Demant, & Branwen, 2016; Van Buskirk, Roxburgh, Naicker, & Burns 2015).

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transactions, and the physical location of their servers. Key here are anonymization services like Tor that hide a computer's IP address when accessing the site (Lewman, 2016); and decentralized and relatively untraceable cryptocurrencies like bitcoin for making payments (Cox, 2016).

Since the closure of the first major drug cryptomarket – Silk Road 1 (hereafter 'SR1′) – by the FBI in October 2013, many similar marketplaces have emerged. Most tend to be short-lived, with longevity hampered more as a result of marketplace scams than law enforcement interventions (Branwen, 2014). Over the past year, we have seen the emergence of single 'vendor shops', often specializing in one or a few drug types. The tally at the time of writing includes 30 multi-vendor primarily drug marketplaces (of which 7 are non-English) and 16 single vendor markets (deepdotweb, 2016).

In spite of their proliferation and phenomenal growth (Aldridge & Décary-Hétu, 2016), cryptomarkets represent only a tiny fraction of the global drugs trade (Aldridge & Décary-Hétu, 2016). Nevertheless, drug cryptomarkets represent a new way of 'doing business', holding the potential to transform local offline markets for illegal drugs by providing a new channel for drug diffusion across locales. The precise mechanisms for diffusion, however, will depend on whether cryptomarkets cater for a retail market only, or whether they serve a wholesale function as well. If these marketplaces serve an exclusively retail function – in which transactions take place only with customers who are drug users buying for their personal use – then the drug diffusing capacity of cryptomarkets will be created insofar as more and more drug users become cryptomarket customers. On the other hand, if cryptomarkets involve wholesale purchases by customers sourcing stock to distribute in local offline markets, then the drug diffusing capacity of these online marketplaces will be substantially increased: cryptomarket-sourced drugs would become available even to drug users who are not themselves cryptomarket customers. Our aim in this paper is to characterize the supply side of cryptomarkets. This will be achieved by identifying the existence of wholesale level transactions on SR1, the drug types associated with these transactions, and the countries from which vendors making wholesale transactions ship, and are likely based. We consider our results in light of their cryptomarkets' potential to facilitate drug diffusion, to reduce violence associated with offline drug markets, and their utility in the form of drug information systems that provide 'early warning' in comparison to existing approaches.

The cryptomarket: an 'anonymous open' drug market that transcends locale

Access to illegal drugs across the globe is uneven. In spite of the globalizing processes that have shaped local drug markets in recent decades (Seddon, 2008), local drugs markets remain structured by international economic relationships between countries (Boivin, 2014) and available and evolving trafficking routes (UNODC, 2012). This is reflected in the highly varying patterns and prevalence of illicit drug taking globally (see for example Degenhardt et al., 2008). Before the advent of Internet-facilitated drug buying, drug users typically sourced their drugs from local retail dealers operating in geographically restricted locales (Reuter, 1983), or via 'social supply', or 'sorting' through friends who did so on their behalf (Aldridge, Measham, & Williams, 2011; Coomber & Moyle, 2013).

Prior to the 1990s, retail drug markets were typically 'open' markets in which dealers sold to any customer – known and unknown (Harocopos & Hough, 2005). The advent of pagers and mobile phone technology shifted many drug markets from 'open' to 'closed', in which dealers sold to known customers, acquiring new ones only through 'trusted' introductions (May & Hough, 2004). Whether open or closed, the number of customers a dealer can transact with in the 'offline' realm is time and space limited: for drugs and cash to change hands, buyers and sellers have to meet. The possibilities for retail drug dealers to expand their customer base is not only restricted by the necessity of accessing customers within geographical reach, but also as a result of local competition, inability to advertise, and the risks involved in expanding illegal operations (Reuter, 1983). Violence within these markets, although rare, is also a risk faced by drug suppliers, who do not have recourse to state institutions when conflict arises (Reuter, 2009), making the expansion of operations for drug dealers a risky proposition.

Drug cryptomarkets represent an important drug market innovation through their capacity to transcend these limitations. Firstly, drug vendors operating on these markets are able to interact with unknown customers, with the trust facilitated via the anonymity mechanisms built in to the marketplace (Martin, 2014). In this sense, we characterize drug cryptomarkets as 'anonymous open' drug markets. Secondly, in contrast to offline drug markets where dealers cannot easily and publicly advertise their services, vendors operating on drug cryptomarkets can openly advertise their products for sale to anyone who accesses the marketplace across the globe, even gaining online 'reputation' scores from the positive (or negative) feedback left by customers in the style of eBay-style online marketplaces. Thirdly, cryptomarket vendors will be less restricted by local competition than their offline counterparts, who must compete with other dealers in fairly tightly restricted geographical locations, or else relocate their operations (Morselli, Turcotte, & Tenti, 2011). Cryptomarket vendors, in contrast, have access to a customer base that is widely geographically dispersed – both within and across national boundaries – potentially making local competition less relevant and the risks associated with market expansion less problematic. As well, cryptomarkets have regulatory mechanisms (escrow, seller and buyer trust metrics, marketplace adjudication of disputes – see Christin, 2013), removing some of the instability in illegal markets that gives rise to conflict and violence. Their location in the virtual sphere may make the violence associated with drug markets, especially where suppliers seek to expand their markets, less likely. By transcending the limitations of geography, all these features of the cryptomarket have the potential to increase the size and reach of the market vendors can access, in comparison to retail drug dealers operating in offline drug markets.

Drug cryptomarkets may therefore provide a new mechanism for the diffusion of specific drugs into new locales in which they were previously unavailable. The diffusion concept has long been used to examine how innovations are spread through social systems (Rogers, 1983). Ferrence (2001), in a review of research applying the diffusion model to drug taking, confirmed its utility for understanding how the use of new drugs or forms of use can spread, but concluded that the model could be improved by incorporating economic availability. Drug cryptomarkets may provide a mechanism not only for the diffusion drugs across locales, but one that allows researchers and policy makers to monitor the availability of specific drugs by examining sales generated on these marketplaces. Cryptomarkets may provide those interested in 'early warning systems' with information that moves beyond that captured by existing approaches.

We might expect however, certainly at this early stage in the development of drug cryptomarkets, that the extent to which drug users are aware of these marketplaces, and willing and able to make purchases from them, will be limited. Research by Barratt et al. (2014), using Global Drugs Survey data, suggests that even among survey respondents who usually buy their own (primarily recreational) drugs, access to drugs via SR1 was not widespread. In Australia, the UK and the USA, 7%, 10% and 18% of the sample (respectively) had consumed drugs purchased via SR1, and just over half of these had self-purchased (so between 5 and 10%).

Although these results suggest that access to drugs via cryptomarkets is not inconsiderable and should be monitored, it is unlikely at this stage that these marketplaces now play a substantial role in drug diffusion solely through purchases made by drug users for their own use. But what if cryptomarkets impact on drug availability even for drug users who are not their customers? Our own observations of SR1 during its time of operation in 2012 and 2013 confirmed the existence of high price/quantity drugs listed for sale, and our preliminary analysis presented in a working paper suggested that these listings generated substantial sales revenue for vendors operating there (Aldridge & Décary-Hétu, 2014). This leads us to question the market level of the cryptomarket: retail? Wholesale? Or both?

Others have characterized SR1 in ways that suggest it functioned primarily for retail sales. Barratt (2012) described this as a kind of 'eBay for drugs', and Christin (2013) referred to the typically small quantities of drugs listed for sale there. Martin (2013) speculated that SR1 might have functioned effectively to bypass the wholesale 'middle' level of the drugs market, linking importers and cultivators directly to drug using customers. If these marketplaces serve an exclusively retail function – in which transactions take place only with customers who are drug users buying for their personal use – then the drug diffusing capacity of cryptomarkets will be created only for those customers, and increased only as more drug users make purchases there. On the other hand, if cryptomarkets involve wholesale level purchases by those involved in profitable resale or social supply activities within friendship networks, then the drug diffusing capacity of these online marketplaces is substantially increased: cryptomarket-sourced drugs become available even to drug users who are not themselves cryptomarket customers.

Aims

The main aim of this paper is to characterize the supply side of one drug cryptomarket, SR1. This will be accomplished in three ways. Firstly, we assess the relative importance of wholesale versus retail transactions on the marketplace, providing an indication of the location in the market hierarchy that this drug cryptomarket occupied. To do so, we use a revised approach to assessing wholesale level transactions than employed in our working paper (Aldridge & Décary-Hétu, 2014). Secondly, we examine the specific drug types associated with wholesale transactions. Doing so will shed light on the particular drugs for which cryptomarkets may particularly facilitate wholesale level diffusion into local drug markets. Thirdly, we examine the countries of operation for vendors that drove the wholesale transactions in this marketplace.

Methodology

Our methodology is that of using 'digital traces' (Décary-Hétu & Aldridge, 2015) in the form of monitoring online dark net marketplace activity by crawling and then scraping the data that result.

Data collection

Our data were collected from SR1. Although this marketplace has now been closed by law enforcement and new markets have taken its place, there remain substantial advantages to providing our analyses in connection to this market. SR1 was the first major and successful drug cryptomarket on which later markets have been modeled. It was growing at the time of our data collection (Aldridge & Décary-Hétu, 2014), and unlike marketplaces since, was not at the time hampered by the mistrust associated with marketplace closures due to law enforcement activities, marketplaces scams and external hacks that have been rife in successor marketplaces (Aldridge & Décary-Hétu, 2016). Our results reported here therefore provide a useful baseline for comparison to assess how later marketplaces have evolved and changed.

We created our own web crawler, DATACRYPTO (Décary-Hétu & Aldridge, 2013), to fetch each of the nearly 11,000 web pages containing listings for the sale of drugs on SR1. Our crawler started from the SR1 home page, indexed the content of the web page for each listing and downloaded them. As the listings contained hyperlinks to vendor profiles, our web crawler also followed and automatically downloaded these. Data were collected between the 13th and the 15th of September 2013. Some vendors retained listings for drugs that were out of stock, and we learned from carefully reading their listings that to discourage buyers from making orders, it was common practice to raise the price by at least an order of magnitude. Doing so allowed vendors to retain the listing until new stock again became available – and critically – to retain positive customer feedback for those listings, thereby encouraging more sales when fresh stock arrived. The extreme values in these highly priced listings would have skewed our results. Soska and Christin (2015) benefited from being able to track listing prices over time to help identify holding prices, but because our data are cross-sectional, we were unable to take this approach. Soska and Christin (2015) also used an automated heuristic that involved removing some high and low priced listings based on price (e.g. over $10,000 USD). We elected not to take this approach, after having discerned through a close inspection that many were 'legitimate' even where these diverged to an extent from modal prices within drug categories. In order not to exclude listings that had been intentionally highly priced by vendors for sale, but to exclude those using high prices to deter purchases – critical for our analysis, so as not to over-estimate wholesale transactions – we inspected all listings priced over USD $10,000 ($n = 103$), and excluded those where vendors referred specifically to using these as 'holding prices' to deter customers from placing orders ($n = 51$). The remaining highly priced items ($n = 52$) were all for very high quantities (weights of a kilo or more), with the exception of some psychedelic drugs (such an NBOMe compounds typically measured in micrograms) and prescription medications (typically sold in milligram quantities), but these also were appropriately high quantity listings. This generated data on 1031 vendors and 10,927 active listings for items in the 'drugs' section of Silk Road.

For the analyses in this paper, we did not rely on the drug categories into which vendors had placed their listings, as we did in our working paper (Aldridge & Décary-Hétu, 2014) because having done so resulted in inaccuracies that we identified after thoroughly cleaning and checking the drug categories. We took the following decisions. The major drug category for 'prescription drugs' in Table 1 of the results includes *all* drugs that were described by vendors as prescription drugs, even though some of these drugs are, for example, also opioids (e.g. oxycodone pills), or stimulants (e.g. methamphetamine pills), and even where vendors did not themselves place these products in the SR1's 'prescription' drug category. The 'opioid' category in Table 1 contains primarily heroin, alongside opium, and other non-prescription opioids. The

Table 1
Mean weight of drugs (g) listed for sale across price categories.

	Number of listings	Mean weight (g)
<$100.00	5328	7.96
$100.01–$500.00	3854	25.13
$500.01–$1000.00	830	90.29
$1000.00+	915	402.17
Total	10,927	58.44

'stimulant' category in the table, likewise, only contains non-prescription stimulants (e.g. cocaine, amphetamine sulphate). We look particularly at 'crystal meth' (when sold as such, and so excluding methamphetamine pills) and 'heroin' in Table 2. This approach ensured that all similar drug types were categorized similarly across the entire dataset. Although there are multiple ways researchers may wish to categorize drug types sold on cryptomarkets, we strongly recommend, therefore, not relying on the categories into which vendors themselves place their listings to accomplish this.

Measurements

We converted the price of a listing from bitcoins to $USD at the rate of $125.10, the average exchange rate on the days of data collection taken from the BTC-e.com exchange. Listings were divided into four categories: those priced at (1) $100.00 or less; (2) $100.01 to $500.00; (3) $500.01 to $1000.00; and (4) over $1000.00. The higher the price of a drug transaction, the more likely that those transactions would have been initiated by customers intending offline distribution. It is not possible to determine, on the basis of the price of a transaction alone – without asking buyers themselves – whether a purchase is for resale or for use. An ounce or two of herbal cannabis can, for example, be the purchase of someone stocking up for daily personal use, or purchase for profitable resale, or resale alongside personal use, or a 'social supply' purchase for sharing in friendship groups where profit is not the key motive (or indeed all of these).

We elected *not* to take a literature-derived approach to estimating typical wholesale transactions made by retail level dealers for a few reasons. Research documenting actual/typical wholesale transactions among retail drug dealers is fairly limited. What research does exist demonstrates such wide variation that any estimates we might derive could be misleading. Taking results reported by Caulkins and Reuter (1998), for example, we see that of the 32 retail drug dealers in their sample, their (sometimes inferred) wholesale purchase price had a mean of (USD) $480, a median of $180, and ranged from $30 to $3000. Associated quantities of wholesale purchase varied similarly. This wide variation has also been noted more recently in connection to retail dealers of recreational drugs in the UK (Taylor & Potter, 2013). In other words, this research teaches us, not that 'wholesale purchase quantities start about *here*', but that drug dealers vary enormously in how much they buy when they source stock. We also have no idea how closely online retail purchases might mirror stock-sourcing purchase patterns for dealers in offline markets. For example, would cryptomarket customers making wholesale purchases do so more or less often than their offline counterparts? This sort of gap in our understanding makes literature-derived estimates of wholesale transaction size on drug cryptomarkets even shakier. Our decision is further influenced by those who point to the 'blurred' boundary between social supply and retail sales (e.g. Chatwin & Potter, 2014). We therefore side-step all of this ambiguity and take a simple, and intentionally arbitrary, approach to distinguishing wholesale from retail transactions on SR1.

Using the four categories of drug listing price, we categorize wholesale level transactions as those over $1000. It is of course possible that transactions at this level will include some customers sourcing supply for personal use or social supply. However, we expect that a majority of transactions conducted for drugs priced at this level will be initiated by customers intent on profitable re-sale or social supply. We acknowledge too that transactions for lower priced drug purchases (for example, between $500 and $1000) may also include stock-sourcing transactions. Our arbitrary – and undoubtedly conservative – criterion of 'over $1000′ provides a useful baseline of comparison for other researchers to assess how later marketplaces have evolved and changed in this regard.

Although wholesale transactions might instead be ascertained with reference to the quantity of a purchase, similar problems to those identified above apply (e.g. the frequency with which a customer intending offline distribution makes restocking purchases). Indeed, price may be a better indicator given that what might be a wholesale quantity for one drug (measured in terms of weight) might not for another. For example, some psychedelic compounds are typically measured and sold in micrograms

Table 2
Estimated monthly revenue for selected drug categories[a] by listing price.

	N	Price	Sum of estimated monthly revenues	Market share	
Cannabis	1235	<$100	$431,752	21%	Total estimated monthly revenues: $2,038,213
(*N* = 2493)	848	$100.01–$500.00	$838,778	41%	
	199	$500.01–$1000.00	$285,557	14%	Market share of listings over $500: 38%
	211	$1000.00+	$482,126	24%	
Ecstasy	341	<$100	$123,813	8%	Total estimated monthly revenues: $1,613,840
(*N* = 1045)	364	$100.01–$500.00	$497,263	31%	
	119	$500.01–$1000.00	$237,821	15%	Market share of listings over $500: 62%
	221	$1000.00+	$754,944	47%	
Opioids	71	<$100	$62,944	22%	Total estimated monthly revenues: $284,972
(*N* = 172)	73	$100.01–$500.00	$193,751	68%	
	12	$500.01–$1000.00	$10,540	4%	Market share of listings over $500: 10%
	16	$1000.00+	$17,736	6%	
Prescription	2024	<$100	$229,135	23%	Total estimated monthly revenues: $999,872
(*N* = 3842)	1466	$100.01–$500.00	$476,318	48%	
	202	$500.01–$1000.00	$109,598	11%	Market share of listings over $500: 29%
	150	$1000.00+	$184,821	18%	
Psychedelics	701	<$100	$203,277	29%	Total estimated monthly revenues: $712,574
(*N* = 1364)	431	$100.01–$500.00	$307,215	43%	
	111	$500.01–$1000.00	$79,227	11%	Market share of listings over $500: 28%
	121	$1000.00+	$122,856	17%	
Stimulants	326	<$100.00	$147,177	11%	Total estimated monthly revenues: $1,330,989
(*N* = 1071)	452	$100.01–$500.00	$668,580	50%	
	145	$500.01–$1000.00	$287,728	22%	Market share of listings over $500: 39%
	148	$1000.00+	$227,504	17%	

[a] The table excludes tobacco, production and cutting agents, and drugs categorized as 'other'.

(e.g. LSD, NBOMe compounds), with other drugs typically measured and sold in grams (e.g. cocaine and DMT). Even those sold in grams can be dosed and re-dosed at very different rates, such that a few grams of DMT might be much more likely to be purchased for redistribution than a few grams of cocaine might be. Making the individual decisions required to ascertain what might be considered wholesale quantities across the many hundreds of different drug types available on cryptomarkets becomes a near impossible task, not least because of the limited information available to guide decision-making in this regard for the many NPS ('novel psychoactive substances') entering these and other markets (Corazza et al., 2013). Making comparisons across drugs with regard to wholesale/retail therefore becomes even more problematic. The advantage of using price to estimate wholesale purchasing is that the can-of-worms opened when looking at quantities is effectively side-stepped.

Looking to legal definitions for guidance in determining 'supply' level quantities was unhelpful. Threshold quantities established for supply offences where these exist across European countries vary enormously, with thresholds for ecstasy, for example, being triggered at points ranging from 1 g (in Hungary) to 450 g (in Austria) (EMCDDA, 2015). Trafficable threshold quantities for heroin, methamphetamine, cocaine and MDMA in most Australian states amount to no more than a few grams for each drug, and although Australian users typically consume less than these amounts in a typical session, users in a 'heavy session' often consumed in excess of quantities potentially triggering a drug supply offence (Hughes, Ritter, Cowdery, & Phillips, 2014). In the USA, base sentencing guidelines for federal trafficking cases (that is, trafficking across state borders) indicate thresholds starting at comparatively higher quantities for some drugs (e.g. 10 g of heroin and 50 g for cocaine), but very low for some others (e.g. 0.5 g pure methamphetamine) (United States Sentencing Commission, 2014). Research on US incarcerated drug offenders confirms that quantities involved could be substantial for traffickers in federal prisons (median of 186 standard retail amounts), but much lower in state prisons (4 standard retail units which, by illustration for cocaine, equals 2 g) (Sevigny & Caulkins, 2004). Given that the majority of US trafficking offences occur at the state level (Caulkins & Chandler, 2006), legal definitions for drug supply activities in the USA also appear to include fairly small quantities. In short, legal thresholds that trigger supply offences are unlikely to be useful indicators for retail level source-stocking quantities, and will lead to over-estimations of wholesale transactions.

We nevertheless present data on quantities of drugs listed for sale. We created an algorithm to convert all listed weights to grams. In the case of listings for pills, we enlisted the help of a pharmacist who weighed different concentrations of nine types of prescription pills (Xanax, Viagra, Valium, Oxycodone, Cialis, Clonazepam, Modafinil, Lorazepam and Levitra). These types of prescription pills represented 39% of all prescription pill listings. Their weights varied from 0.05 to 0.61 g per pill with a mean of 0.19 g (SD = 0.14; CV = 0.71). We used the same average weight for ecstasy tablets. Given the limited variance in weight, this mean was multiplied by the number of pills in the listing.

In order to assess the relative importance of transactions at the wholesale level, we calculated an estimate of monthly revenues generated by each listing based on the number of customer reviews held for each listing, with a sum of all reviews operating as a proxy for transactions generated by the listing. We then multiplied the number of transactions in the last 31 days for a listing by its price to derive an estimate of monthly revenue generated by the listing. The count of customer reviews closely mirrors actual transactions for a listing. To ascertain this, we summed reviews across all a vendor's listings and compared the result to SR1's own 'vendor transactions' metric. We did so only for vendors for whom SR1's own metric indicated sales totalling fewer than 300, since this was the top score for SR1's metric. Doing so, we found that our transaction count using customer reviewers captured 88% of SR1's 'vendor transactions' metric, suggesting that our method captures most of the transactions likely to have been generated by a listing; that is, most customers tended to give feedback on their purchases. Leaving feedback was, moreover, strongly encouraged by vendors in their listings. Nevertheless, our transaction count for listings will exclude our estimated 12% of transactions made by customers who did not leave feedback, as well as the unknowable number of 'stealth' listings not publicly available. Our measure of estimated monthly revenues should not be interpreted as reflecting actual revenues over the period, as some vendors will have been relative newcomers. Our revenue variable should therefore be interpreted as a metric for the relative importance of the different levels of prices of listings. It allows us to address our aims by examining estimated monthly revenue generation at the wholesale level for drugs across all listings, within drug categories and specific drug types, and by country in which vendors are based.

Results

For all drugs sold on SR1, just under half (49%) of all listings were priced under $100. Although by far the most numerous, these listings generated only 17% of estimated monthly revenues. The greatest proportion of estimated revenue was generated by listings in the $100–$500 range (43%), and although some of these purchases will have included customers sourcing stock for profitable resale, many will also have been drug users making purchases for personal or shared use. Taking all transactions for purchases priced over $1000, 26% of all estimated monthly revenue generated on SR1 was derived from wholesale-level transactions.

Wholesale level transactions by quantity

Table 1 shows the mean weight of drugs listed for sale across the four price categories we created. The mean weight of a drug listed for sale increased as price increased, with listings priced over $1000 having a mean weight of 402.17 g. Given that weights in the price category below ($500–$1000) were less than a quarter (90.29 g) of that found for our $1000 wholesale criteria cut-off, this finding provides some validation for our approach to designating wholesale transactions as those above $1000.

Drugs associated with wholesale level transactions

Table 2 shows, for each of the six major drug categories included, the number of listings in each price category, the estimated monthly transactions and revenue, and the proportion of overall revenue generated within each listing price category.

Wholesale activity was more substantial for some drug categories than others. This was greatest for drugs in the 'ecstasy' category (just over $750,000); representing 42% of estimated wholesale revenue across all the drug categories presented, and 47% of estimated wholesale revenue for ecstasy sales. Cannabis followed with nearly $500,000 in estimated revenue generated by wholesale level transactions, nearly a quarter of the revenue for the cannabis category. Psychedelics, prescription drugs, and stimulants each generated less than $230,000 in wholesale level revenues, with wholesale revenues representing less than 20% of the estimated revenues within each of these categories. Opioids had the fewest listings overall, generated only just over $17,000 in wholesale level revenue, and the proportion of revenue that was wholesale for opioids was only 6%.

Table 3
Estimated monthly revenue for specific drug types priced over USD $1000.

	Number of listings priced $1000 USD+	Share of all listings	Estimated monthly revenues	Market share
Herbal cannabis	127	10%	$420,250	28%
MDMA powder/crystal	81	21%	$342,500	44%
Ecstasy pills	76	17%	$217,250	40%
MDMA-type[a]	64	29%	$195,167	66%
Benzodiazepines	47	5%	$148,417	33%
Prescription stimulants[b]	83	10%	$102,583	22%
Phenethylamines[c]	72	12%	$101,667	42%
Cocaine	56	14%	$71,000	11%
Crystal meth	26	15%	$62,250	21%
Ketamine	13	13%	$37,417	23%
Other cannabis products[d]	23	4%	$33,583	16%
Hash	31	6%	$28,333	9%
Prescription opioids[e]	68	10%	$23,333	8%
Heroin	9	8%	$17,750	6%
LSD/other lysergides	9	4%	$15,833	6%
Tryptamines[f]	39	8%	$5333	3%

[a] MDA, 5-ap and 6-ap compounds, and methylone.
[b] Adderall, Modafinil, methamphetamine pills, ephedrine, phentermine, dexedrine.
[c] NBOMe compounds, 2-c compounds, 3-c compounds, allylescaline, proscaline, DOM and DOC.
[d] Edibles, extracts and seeds.
[e] Oxycodone, Tramadol, hydrocodone, Fenantyl, morphine, methadone, buprenorphine codeine.
[f] DMT (and related) compounds, ayahuasca, mushrooms (and related).

Table 3 contains the specific drug types that generated any wholesale-level revenue. The table includes, for listings priced over $1000: the number, their share of total listings for the drug type, estimated monthly revenues and the market share for the drug type.

Herbal cannabis generated the highest revenue of any single drug, in contrast to the other cannabis type drugs that generated much less (hash and other cannabis products). The largest wholesale level revenues were generated for drugs typically characterized as 'party' drugs. 'Ecstasy' type drugs generated the greatest wholesale-level revenue, taken together: MDMA-type pills, MDMA powder/crystal and ecstasy pills; and these drugs had the most substantial levels of wholesale market share. Other 'party' and psychedelic drugs generated less wholesale revenue: phenethylamines, ketamine, LSD, and tryptamines.

Cocaine and prescription stimulants are associated with both 'party' use and as drugs of dependency. These generated substantial wholesale revenue in the mid-range of our findings. Crack cocaine in contrast, although sold on SR1, generated no wholesale revenue and so is absent in the table. Drugs associated with dependency and self-medication also generated wholesale revenue. Benzodiazepines generated the highest wholesale revenues after recreational/party drugs. Wholesale activity was also evident for crystal meth, prescription opioids, and heroin, but had substantially less wholesale revenue than found for recreational and party drugs.

Countries associated with wholesale level transactions

Table 4 lists the countries from which vendors shipped drugs that generated any wholesale-level revenue. The table includes, for listings priced over $1000: their number, their share of total listings for each country, and estimated monthly revenues and market share for each country.

Vendors were located in 41 countries around the world, but wholesale level transactions were restricted to vendors in only 11 countries. The USA had the highest level of wholesale revenue generation, closely followed by the Netherlands and Canada. Sweden, Spain and India generated comparatively very little revenue from wholesale level transactions. China stands out in the table because nearly half (46%) of the listings for vendors in this country were priced at the wholesale level, compared to substantially fewer in all other countries. Belgium and Germany are also notable in this regard, although, overall revenue generation and wholesale share of listings was less than for China.

Table 4
Estimated monthly revenue by vendor country for listings priced over USD $1000.

	Number of listings priced $1000 USD+	Share of all listings	Estimated monthly revenues	Market share
USA	165	5%	$440,500	24%
Netherlands	131	12%	$365,917	20%
Canada	108	15%	$302,750	16%
China	182	46%	$224,167	12%
UK	84	7%	$160,333	9%
Australia	51	7%	$132,750	7%
Germany	73	14%	$116,667	6%
Belgium	13	20%	$99,750	5%
Sweden	9	3%	$5333	<1%
Spain	26	6%	$2667	<1%
India	14	1%	$1167	<1%

Discussion

Cryptomarkets offer a completely new distribution channel for illicit drugs. Their growth in and resilience to law enforcement efforts and marketplace scams (see Soska & Christin, 2015) suggests that the importance of cryptomarkets for illicit drug purchasing is likely to increase in coming years. We began by characterizing drug cryptomarkets as 'anonymous open' marketplaces that allow retail drug dealers to transcend the geographical limitations of 'closed' offline drug markets, potentially increasing the diffusion of drugs into locations in which they were previously unavailable, or where availability was limited. Cryptomarkets may therefore have the potential to kickstart changes in the patterns and prevalence of drug use in the locations they are sold. Our analysis focused on one of the mechanisms through which this might occur: the cryptomarket as a wholesale marketplace.

The mechanisms through which an anonymous open drug market can facilitate drug diffusion will depend on whether these marketplaces serve a wholly retail function, or whether they also supply wholesale stock for redistribution. Initial characterizations of cryptomarkets in the literature implied a retail marketplace location (Barratt, 2012; Christin, 2013; Martin, 2013). In contrast, we estimate that around one quarter of the revenue generated on SR1 resulted from wholesale priced transactions. Our findings therefore suggest that cryptomarkets may be understood as a virtual broker, linking wholesalers with offline retail-level distributors. This is an important finding because wholesale activity may increase the capacity of cryptomarkets to diffuse drugs across locales – therefore reaching even drug users who are not themselves cryptomarket customers. This can occur as a result of cryptomarket customers who are themselves drug dealers or user-dealers making large purchases for profitable offline resale (Aldridge & Décary-Hétu, 2014), or by customers making purchases for minimally commercial social supply among friendship groups (Coomber & Moyle, 2013). Drug diffusion across locales might also be facilitated by cryptomarkets via drug users making personal use-sized purchases; but diffusion will remain fairly limited until we see much more substantial increases in purchases made by drug users than we currently find (see Barratt et al., 2014).

If cryptomarkets through their wholesale operations have the capacity to facilitate drug diffusion, for which drugs is this most likely? Our findings pointed to ecstasy as the big wholesale story on SR1, both in terms of overall revenue and relative proportion of sales at this level. After herbal cannabis, we found other 'party' drugs were also important at the wholesale level, including a broad range of psychedelic drugs. The fact that wholesale transactions were as concentrated as we found them to be in the Netherlands, Belgium and China may be related to these countries being producer countries for these drugs (UNODC, 2014) and thus well placed to transact with customers at the wholesale level. Martin (2013) suggested that cryptomarkets may link vendors in producing countries directly with consumers; our results suggest that where this occurs, it will at least in part be mediated as a result of this drug cryptomarket operating at the middle level of the market, rather than (only) through bypassing it. We are already witnessing the diversification and expansion in the production, trade, supply routes and user-base locations for ecstasy and other amphetamine-type drugs (UNODC, 2014), and for cannabis (UNODC, 2015). Given the sizeable and predominant wholesale trade for these drugs that we found on SR1, it is possible that cryptomarkets may function to further this diversification and expansion, at least in part by diffusing these substances to locations where supply routes have yet to be established.

The extent to which cryptomarkets may link vendors located in countries where these drugs are produced, synthesized or cultivated with customers around the world may be specific to certain drug types. It is perhaps not surprising that we saw a predominance of widespread wholesale activity for herbal cannabis, given its now global cultivation (UNODC, 2015) and for ecstasy-type drugs that are manufactured synthetically. In contrast, the utility of cryptomarkets as suitable for vendors in producer countries for drugs like heroin or cocaine seems likely to be limited at best. The production of these drugs involves multiple stages of cultivation and refinement in areas (e.g. Afghanistan, South America) which, as Martin (2014, p. 58) points out, lack "the techno-logical infrastructure necessary to sell goods via a cryptomarket such as internet-enabled computers and secure postal systems". It seems likely therefore that cryptomarkets may only partially mirror the structure of existing (albeit shifting) global drug distribution trafficking routes from 'producer' to 'consumer' countries.

Barratt et al. (2014) found that survey respondents who used SR1 often cited the range of drugs available to them as key in their decision to make purchases there. We found that wholesale activity was substantial for specific drug types that included a wide range of individual compounds (e.g. psychedelic phenethylamines, tryptamines, and 'MDMA-type' drugs), many first synthesized by Alexander Shulgin (Shulgin & Shulgin, 1991, 1997) but individually often rare and difficult to access in local offline markets. To the extent that cryptomarket customers include drug dealers, social suppliers, or user-dealers sourcing stock for offline distribution, local offline drug markets may also be transformed by creating access to a wider range of drugs available for purchase, particularly for rarer substances.

Although herbal cannabis and party drugs were dominant in terms of wholesale activity on SR1, some drugs associated with dependence and self-medication were evident: wholesale transactions for benzodiazepines and prescription stimulants were substantial, and generated estimated revenue exceeded only by herbal cannabis and ecstasy-type drugs. Cocaine, crystal meth, heroin and prescription opioids generated wholesale revenue, albeit in lesser amounts. We can speculate that the characteristics associated with particular drug types may make them easier or more risky to package and ship in wholesale quantities (e.g. odour, bulk, perceived detectability) and perhaps drive vendor decisions to supply these drugs online given the requirement for postal delivery. However, it was not obvious in our analysis that drug characteristics one might expect to deter vendors from making wholesale shipments did so: herbal cannabis in particular (known for its strong odour) generated substantial bulk sales. Our reading of the discussion forum associated to SR1 suggested that vendors used a range of packaging strategies to disguise odour.

Limitations of our study and directions for future research

There are limitations to what we can learn about the capacity for drug cryptomarkets to contribute to drug diffusion using the digital trace methodology we employed. Although vendors do list where they are willing to ship their drugs, data generated by customer reviews do not allow us to identify the countries in which customers were based. This 'supply side' only approach limits the utility of cryptomarket data to give us the full picture of drug diffusion. Relatedly, some customers making stock sourcing purchases for re-distribution may do so for redistribution on the very same marketplace – or in the post SR1 era, on competing cryptomarkets. Where this occurs, the drug diffusion facilitated by wholesale cryptomarket purchasing will not occur in local offline markets. Future researchers should attempt to ascertain the extent to which the drugs purchased through cryptomarkets are recycled on those marketplaces. There is no way to determine this with the supply side data researchers have available to them from cryptomarkets, so other methods, like self-report surveys, will be required.

One assumption we might make is that customers are likely to prefer making domestic purchases, and vendors are likely to prefer to make domestic shipments, with both parties seeking to reduce the risks of interception at borders and the delays and increased costs associated with international shipping (Décary-Hétu, Paquet-Clouston, & Aldridge, 2016). With this assumption in mind, we might surmise that diffusion is likely to occur most substantially within rather than across international boundaries. Cryptomarkets have the theoretical capacity to create a unified and global drug market; it seems likely, however, that even to the extent that this occurs, cryptomarkets may also substantially replicate, at the cross-country level, existing offline patterns of distribution that are structured by international economic relationships between countries (Boivin, 2014) and available and evolving trafficking routes (UNODC, 2012). The capacity for drug cryptomarkets to transform local drugs markets may take place as often within national boundaries, for example between rural and urban areas, or among cities within individual countries. Future research will need to employ survey or interview techniques to ascertain the geographical locations of cryptomarket customers in relation to the vendors from whom they purchase, although the samples on which such methodologies are based will lack the 'full market' picture that is a strength of digital trace methodologies (Décary-Hétu & Aldridge, 2015). A related and potentially fruitful avenue for future research will be to establish the precise way in which drug cryptomarkets interact with existing and evolving offline global drug distribution trafficking routes.

Our cut-off point (transactions for listings priced over $1000) for assessing wholesale activity is arbitrary. Although we feel reasonably confident in our conclusion that a substantial proportion of revenue generated on SR1 was at the wholesale level, we can have little confidence that our precise estimates in this regard are meaningful. Nevertheless, our finding that listing prices corresponded in a predictable way to large quantity listings gives us confidence that highly priced listings were also high quantity listings, with listings priced over USD $1000 having an average weight of under half a kilo (402.17 g). Our approach provides other researchers studying cryptomarkets with a simple criterion that

can be used to track changes in wholesale activity in new cryptomarkets. There is no way to determine whether drugs are intended for resale/social supply/use without asking customers making their purchases, and so survey and interview methodologies may shed light here, but given the wide range of price/quantity transactions across drug dealers when they source stock (e.g. Caulkins & Reuter, 1998; Taylor & Potter, 2013) doing so may not take us far in developing any more precise estimates for application using our digital trace methodology. The crude approach we took here of using an arbitrary price cut-off has some advantages over vastly more complex quantity-weight driven approaches, but more research is required to establish the complex relationship between price and quantity indicators in stock-sourcing activities for retail level drug dealers, both online and offline. Much research yet remains to be done to characterize the range of sales made on drug cryptomarkets, whether stock-sourcing or personal use purchasing, including how much specialism we see by drug type (that is, the relative balance between mono and poly-drug supply activities), and the use of quantity discounts.

The 'supply side' data we employed for this study cannot shed light on the population prevalence of drug use. Nevertheless, the transactions and price data it contains provide something of a 'mirror' of demand side purchasing, and by extension, use. Sales on drug cryptomarkets can be used to monitor the availability of existing and new substances, and provide improvements to the 'early warning' approaches that have been criticized for failing to provide useful warning until changes in drug consumption are already embedded (Griffiths, Vingoe, Hunt, Mounteney, & Hartnoll, 2000). Although internet-derived data is now being used in drug monitoring systems (e.g. Deluca et al., 2012) data from cryptomarkets provide added value here. By looking at the revenue generated by the sales of particular drugs, as opposed only to those listed for sale or discussed on internet drugs forums, we gain a better insight into actual availability insofar as particular drugs generate sales, and therefore use. This added value is further increased when we focus on wholesale revenue generation, providing a gauge of how cryptomarkets may be impacting drug availability including and beyond those who access them as customers. Cryptomarkets provide data not only on the type of drugs offered for sale, but also the frequency of drug purchase – a better indicator of availability – alongside their transaction price and geographical origin. In these ways drug cryptomarkets provide a rich source of drug monitoring data, and should therefore be monitored closely to identify trends and patterns in purchasing, and by extension, use. Future research would also benefit by comparing trends and patterns generated through the 'digital traces' methodology we have employed, and comparing these to population surveys that include questions about online drug purchasing.

Because we see evidence that SR1 partly served a wholesale market function, this means that where drug dealers source stock for resale in local offline drugs markets, they conduct their supply sourcing transactions in a 'virtual' location. An implication, therefore, is the potential for drug cryptomarkets to reduce the possibilities for violence that tend to be associated with offline markets at the middle and upper levels (Caulkins & Reuter, 2009). Traditional illicit markets do not have recourse to state institutions to adjudicate disputes; cryptomarkets, themselves mini-ecosystems, have their own regulatory mechanisms (escrow, seller and buyer trust metrics, marketplace adjudication of disputes), removing some of the unstable factors in illegal markets that may otherwise give rise to conflict and violence. Our digital trace methodology cannot measure violence or other forms of conflict connected to transactions that take place on cryptomarkets, but researchers using different methods could fruitfully examine this hypothesis. Barratt, Ferris, and Winstock (2014), employing survey methodology, found that drug users making cryptomarket purchases were less likely to report violence and threats than those making offline purchases.

Although it may seem self-evident that the virtual location of online drugs markets should reduce violence insofar as interactions there occur in virtual rather than physical space, this potential harm reduction capacity of cryptomarkets is likely to have limitations. Cryptomarkets remain 'anchored' in offline drug markets, with vendors there often purchasing drugs offline to sell online, and stock-sourcing cryptomarket customers about to make their retail sales in offline markets. These anchors in offline drugs markets mean that cryptomarket users involved in drug supply activities may still be victims and perpetrators of violence connected to these face-to-face transactions. As well, harm can manifest in ways other than physical violence: threats or damage to reputation, 'doxing' (hacking and then threatening to expose identity) and other forms of blackmail, theft and fraud, and cyberbullying. Finally, the violence associated to drug markets may be culturally, politically and socially conditioned (Bourgois, 2003; Johnson, Golub, & Dunlap, 2006) rather than arising solely as a function of the illegal market itself. To the extent that these external conditions remain unchanged, the ability of the cryptomarket to reduce violence and conflict, although promising, may have limitations.

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References

Aldridge, J., & Décary-Hétu, D. (2014). *Not an 'Ebay for Drugs': The cryptomarket "Silk Road" as a paradigm shifting criminal innovation*. Available at SSRN: http://ssrn.com/abstract=2436643

Aldridge, J., & Décary-Hétu, D. (2015). A response to Dolliver's "Evaluating drug trafficking on the Tor Network: Silk Road 2, the sequel". *International Journal of Drug Policy, 26*(11), 1124–1125.

Aldridge, J., & Décary-Hétu, D. (2016). Cryptomarkets and the future of illicit drug markets. In EMCDDA (Ed.), *Internet and drug markets, EMCDDA insights* (pp. 23–30). Luxembourg: Publications Office of the European Union.

Aldridge, J., Measham, F., & Williams, L. (2011). *Illegal leisure revisited: Changing patterns of alcohol and drug use in adolescents and young adults*. London: Routledge.

Barratt, M. J. (2012). Silk Road: EBay for drugs. *Addiction, 107*(3), 683.

Barratt, M. J., Ferris, J. A., & Winstock, A. A. (2016). Safer scoring? Cryptomarkets, threats to safety and interpersonal violence. *International Journal of Drug Policy, 35*, 24–31.

Barratt, M. J., Ferris, J. A., & Winstock, A. R. (2014). Use of Silk Road, the online drug marketplace, in the United Kingdom, Australia and the United States. *Addiction, 109*(5), 774–783.

Boivin, R. (2014). Risks, prices, and positions: A social network analysis of illegal drug trafficking in the world-economy. *International Journal of Drug Policy, 25*(2), 235–243.

Bourgois, P. I. (2003). *In search of respect: Selling crack in El Barrio* (2nd ed.). Cambridge: Cambridge University Press.

Branwen, G. (2014). *DNMs: By the numbers*. Retrieved from http://www.reddit.com/r/DarkNetMarkets/comments/2r58vs/2014_in_dnms_by_the_numbers/

Caulkins, J. P., & Chandler, S. (2006). Long-run trends in incarceration of drug offenders in the United States. *Crime & Delinquency, 52*(4), 619–641.

Caulkins, J. P., & Reuter, P. (1998). What price data tell us about drug markets. *Journal of Drug Issues, 28*, 593–612.

Caulkins, J. P., & Reuter, P. (2009). Towards a harm-reduction approach to enforcement. *Safer Communities, 8*(1), 9–23.

Chatwin, C., & Potter, G. (2014). Blurred boundaries: The artificial distinction netween "use" and "supply" in the U.K. cannabis market. *Contemporary Drug Problems, 41*(4), 536–550.

Christin, N. (2013). *Traveling the Silk Road: A measurement analysis of a large anonymous online marketplace*. Paper Presented at the Proceedings of the 22nd International Conference on World Wide Web.

Coomber, R., & Moyle, L. (2013). Beyond drug dealing: Developing and extending the concept of 'social supply'of illicit drugs to 'minimally commercial supply'. *Drugs: Education, Prevention and Policy, 21*(2), 157–164.

Corazza, O., Assi, S., Simonato, P., Corkery, J., Bersani, F. S., Demetrovics, Z., et al. (2013). Promoting innovation and excellence to face the rapid diffusion of Novel Psychoactive Substances in the EU: The outcomes of the ReDNet project. *Human Psychopharmacology: Clinical and Experimental, 28*(4), 317–323.

Cox, J. (2016). Staying in the shadows: The use of bitcoin and encryption in cryptomarkets. In EMCDDA (Ed.), *Internet and Drug Markets, EMCDDA Insights* (pp. 41–47). Luxembourg: Publications Office of the European Union.

Décary-Hétu, D., & Aldridge, J. (2013). *DATACRYPTO: The dark net crawler and scraper*.

Décary-Hétu, D., & Aldridge, J. (2015). Sifting through the net: Monitoring of online offenders by researchers. *European Review of Organised Crime, 2*(2), 122–141.

Décary-Hétu, D., Paquet-Clouston, M., & Aldridge, J. (2016). Going international. Risk taking and the willingness to ship internationally among drug cryptomarket vendors. *International Journal of Drug Policy, 35*, 69–76.

deepdotweb (2016). *Updated: List of dark net markets (Tor & I2P)*. Retrieved from https://www.deepdotweb.com/2013/10/28/updated-llist-of-hidden-marketplaces-tor-i2p/

Degenhardt, L., Chiu, W.-T., Sampson, N., Kessler, R. C., Anthony, J. C., Angermeyer, M., et al. (2008). Toward a global view of alcohol, tobacco, cannabis, and cocaine use: Findings from the WHO World Mental Health Surveys. *PLoS Med, 5*(7), 1053–1067.

Deluca, P., Davey, Z., Corazza, O., Di Furia, L., Farre, M., Flesland, L. H., et al. (2012). Identifying emerging trends in recreational drug use: Outcomes from the Psychonaut Web Mapping Project. *Progress in Neuro-Psychopharmacology and Biological Psychiatry, 39*(2), 221–226.

Dolliver, D. S. (2015a). Evaluating drug trafficking on the Tor network: Silk Road 2, the Sequel. *International Journal of Drug Policy, 26*(11), 1113–1123.

Dolliver, D. S. (2015b). A rejoinder to authors: Data collection on Tor. *International Journal of Drug Policy, 26*(11), 1128–1129.

EMCDDA (2015). *Threshold quantities for drug offences*. Retrieved from http://www.emcdda.europa.eu/html.cfm/index99321EN.html-T2

Ferrence, R. (2001). Diffusion theory and drug use. *Addiction, 96*(1), 165–173.

Griffiths, P., Vingoe, L., Hunt, N., Mounteney, J., & Hartnoll, R. (2000). Drug information systems, early warning, and new drug trends: Can drug monitoring systems become more sensitive to emerging trends in drug consumption? *Substance Use & Misuse, 35*(6–8), 811–844.

Harocopos, A., & Hough, M. (2005). *Drug dealing in open-air markets.*. US Department of Justice: US Department of Justice, Office of Community Oriented Policing Services.

Hughes, C., Ritter, A., Cowdery, N., & Phillips, B. (2014). *Australian threshold quantities for 'drug trafficking': Are they placing drug users at risk of unjustified sanction?* Canberra: Australian Institute of Criminology.

Johnson, B., Golub, A., & Dunlap, E. (2006). The rise and decline of hard drugs, drug markets, and violence in inner-city New York. In A. Blumstein & J. Wallman (Eds.), *The crime drop in America* (pp. 164–206). Cambridge: Cambridge University Press.

Lewman, A. (2016). Tor and links with cryptomarkets. In EMCDDA (Ed.), *Internet and drug markets, EMCDDA insights* (pp. 33–40). Luxembourg: Publications Office of the European Union.

Martin, J. (2013). Lost on the Silk Road: Online drug distribution and the 'cryptomarket'. *Criminology and Criminal Justice, 14*(3), 351–367.

Martin, J. (2014). *Drugs on the dark net: How cryptomarkets are transforming the global trade in illicit drugs*. Palgrave Macmillan.

May, T., & Hough, M. (2004). Drug markets and distribution systems. *Addiction Research and Theory, 12*(6), 549–563.

Morselli, C., Turcotte, M., & Tenti, V. (2011). The mobility of criminal groups. *Global Crime, 12*(3), 165–188.

Munksgaard, R., Demant, J., & Branwen, G. (2016). A replication and methodological critique of the study ''Evaluating drug trafficking on the Tor Network''. *International Journal of Drug Policy, 35*, 92–96.

Reuter, P. (1983). *Disorganized crime: The economics of the visible hand*. Cambridge, MA: MIT Press.

Reuter, P. (2009). Systemic violence in drug markets. *Crime, Law and Social Change, 52*(3), 275–284.

Rogers, E. M. (1983). *Diffusion of innovations* (3rd ed.). New York: Free Press.

Seddon, T. (2008). Drugs, the informal economy and globalization. *Economics, 35*(10), 717–728.

Sevigny, E. L., & Caulkins, J. P. (2004). Kingpins or mules: An analysis of drug offenders incarcerated in federal and state prisons. *Criminology & Public Policy, 3*(3), 401–434.

Shulgin, A., & Shulgin, A. (1991). *PiHKAL: A chemical love story*. Berkeley, CA: Transform Press.

Shulgin, A., & Shulgin, A. (1997). *TiHKAL: The continuation*. Berkeley, CA: Transform Press.

Soska, K., & Christin, N. (2015). Measuring the longitudinal evolution of the online anonymous marketplace ecosystem. *Paper Presented at the USENIX Security '15*.

Taylor, M., & Potter, G. R. (2013). From ''social supply'' to ''real dealing'': Drift, friendship, and trust in drug dealing careers. *Journal of Drug Issues, 43*(4), 392–406.

United States Sentencing Commission (2014). *Chapter Two – Offense Conduct; Part D – Offenses Involving Drugs and Narco-Terrorism. 2014 Guidelines Manual*. Retrieved from http://www.ussc.gov/guidelines-manual/2014/2014-chapter-2-d

UNODC (2012). *World Drugs Report 2012*. Vienna: United Nations Office on Drugs and Crime.

UNODC (2014). *World Drug Report 2014*. Vienna: United Nations Office on Drugs and Crime.

UNODC (2015). *World Drug Report 2015*. Vienna: United Nations Office on Drugs and Crime.

Van Buskirk, J., Roxburgh, A., Naicker, S., & Burns, L. (2015). Response to Dolliver – Evaluating drug trafficking on the Tor network. *International Journal of Drug Policy, 26*(11), 1113–1123.

Van Hout, M. C., & Bingham, T. (2014). Responsible vendors, intelligent consumers: Silk Road, the online revolution in drug trading. *International Journal of Drug Policy, 25*(2), 183–189.