Buying drugs on a Darknet market: a better deal? Studying the online illicit drug market through the analysis of digital, physical and chemical data.

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Abstract

Darknet markets, also known as cryptomarkets, are websites located on the Darknet and designed to allow the trafficking of illicit products, mainly drugs. This study aims at presenting the added value of combining digital, chemical and physical information to reconstruct sellers' activities. In particular, this research focuses on Evolution, one of the most popular cryptomarkets active from January 2014 to March 2015.
Evolution source code files were analysed using Python scripts based on regular expressions to extract information about listings (i.e., sales proposals) and sellers. The results revealed more than 48,000 listings and around 2700 vendors claiming to send illicit drug products from 70 countries. The most frequent categories of illicit drugs offered by vendors were cannabis-related products (around 25%) followed by ecstasy (MDA, MDMA) and stimulants (cocaine, speed). The cryptomarket was then especially studied from a Swiss point of view. Illicit drugs were purchased from three sellers located in Switzerland. The purchases were carried out to confront digital information (e.g., the type of drug, the purity, the shipping country and the concealment methods mentioned on listings) with the physical analysis of the shipment packaging and the chemical analysis of the received product (purity, cutting agents, chemical profile based on minor and major alkaloids, chemical class). The results show that digital information, such as concealment methods and shipping country, seems accurate. But the illicit drugs purity is found to be different from the information indicated on their respective listings. Moreover, chemical profiling highlighted links between cocaine sold online and specimens seized in Western Switzerland. This study highlights that (1) the forensic analysis of the received products allows the evaluation of the accuracy of digital data collected on the website, and (2) the information from digital and physical/ chemical traces are complementary to evaluate the practices of the online selling of illicit drugs on cryptomarkets.

Keywords: Cryptomarket ; Cocaine ; Drug profiling ; Evolution market ; Concealment techniques ; Source codes.

1 Introduction

The online trading of drugs is a criminal activity that may take various forms. For example, new psychoactive substances are already distributed through the Web, due to the different legal status of these substances from one country to another [1]. Prescription drugs are also sold online with consumers redirected toward online pharmacies through massive spam campaigns [2]. Besides, online selling of traditional illicit drugs (cocaine,

heroin and cannabis) became very popular with the creation Silk Road, in 2011. Markets such as Silk Road are commonly referred to as cryptomarkets, or Darknet markets (DNM). In this context, the Darknet is a set of networks within the Internet, based on peer-to-peer technologies as part of encryption processes [3]. A cryptomarket is an online website, on which it is possible to trade illicit goods – mainly illicit drugs – while the identity of sellers, consumers and administrators remains concealed. This anonymity is ensured because cryptomarkets relies on several encryption features. First, cryptomarkets are hosted on the Darknet, accessing them requires a specific communication protocol such as an onion routing. Connections are then established through a sequence of nodes, each of them having encryption features. Some web browsers are specifically implemented to use an onion routing. The most popular, and first to be released, is the TOR browser (The Onion Router) [4]. However, other networks based on enhanced routing techniques are also available, such as I2P (Invisible Internet Project) [5]. Moreover, communications between participants are encrypted as well, using PGP (Pretty Good Privacy) cryptography, which implies the sharing of public keys on the marketplace [6-8]. Lastly, cryptocurrencies – mainly bitcoins – are the exclusive payment method on cryptomarkets. Transactions in bitcoins are requested by buyers and approved collectively through the bitcoin system. For this reason, bitcoin is not a currency centralised by a bank or guaranteed, nor controlled, by a government [9].

After Silk Road was shut down in October 2013, several other cryptomarkets rose on the Darknet [10]. One of them, Evolution, was launched on January 14, 2014 and shut down on March 18, 2015. By the end of 2014, Evolution was one the major active cryptomarkets, along with Agora. Their success may be explained by the fact that they survived after Operation Onymous, an international operation held in early October 2014 aiming at shutting down several cryptomarkets [11]. Evolution transactions were based on an escrow system, meaning basically that, once a transaction is placed, Evolution's administrators will hold the amount of bitcoins involved until the buyer indicates he received the product. Besides, a feedback system was implemented, allowing consumers to evaluate any vendor or transaction. Vendors were ranked based on their number of transactions and the quality of the feedbacks they received (i.e. positive, negative or neutral). These features show how important are the trust and the reputation among a cryptomarket community [12]. As a cryptomarket grows, the number of bitcoins held in escrow may become huge and constitute a target for hackers or even administrators themselves. This may have led to the shutting down of Evolution on March 18, 2015, since it is hypothesised that the administrators may have "exit scammed" [13].

Ross Ulbricht's – founder of Silk Road – trialled and sentenced in 2015 raised the attention of the media and wider public for trafficking through the Darknet. However, as mentioned by Martin [14], the media's sensational facts are sometimes exaggerated and misleading, revealing the need for a better understanding of the cryptomarkets structure. From an institutional point of view, the United Nations Office on Drugs and Crime (UNODC) emphasised the need to acquire more information about transactions occurring on the Darknet, arguing that it would grow in importance in the future [15]. So far, academic research regarding cryptomarkets is essentially about Silk Road. Some of the studies give an insight and conceptualise the notion of cryptomarket [16 ; 17]. Others aimed at estimating the revenue of sellers and at characterising the business model of cryptomarkets [18 ; 19]. Soska and Christin [8] proposed a detailed analysis of cryptomarkets environment through data obtained over a two-years monitoring period. They studied various aspects such as sales volumes, offered products or activity of vendors and compared several cryptomarkets. Interviews of Silk Road vendors [20] and users [21], as well as discussion threads analyses [22], were also conducted to describe interactions within a cryptomarket community. The authors emphasised notably various discussions about shipping methods and packaging, including measures and techniques to avoid packages interception. Subsequently, Silk Road and Silk Road 2 – a new version launched in November 2013 – were compared [23]. Methodological questions about the comparison of cryptomarkets were raised following this research publication and led to a debate among researchers [24-26].

General monitoring of Darknet marketplaces constitutes a field of research on its own. For instance, institutions such as the National Drug & Alcohol Research Center of the University of New South Wales (see http://ndarc.med.unsw.edu.au) provides periodically trends about cryptomarkets, from an Australian perspective. The Global Drug Policy Observatory of the Swansea University (see http://www.swansea.ac.uk/gdpo) also publishes situation analysis in the field of drug policy, including Darknet and cryptomarkets related aspects.

The purpose of this article is to provide a better understanding of the purchase process of illicit drugs on a cryptomarket. Our first hypothesis is that the accuracy of the information available online can be evaluated through orders. Thus, digital data extracted from the cryptomarket Evolution were analysed to draw an overview of illicit drugs distribution and assess the most popular products offered on the market. Besides, it allows estimating the number of active vendors and their number of transactions. Illicit drugs were then purchased on Evolution. Shipping and packaging modus operandi were studied. Furthermore, qualitative and quantitative analyses as well as chemical profiling of the purchased illicit drugs were performed. These results are used to test out second hypothesis which assumes that forensic analysis of the products can be used to evaluate if cryptomarkets are an extension of the traditional market or, on the opposite, a separate market with only a few relationships with the later.

2 Methodology

2.1 Digital data

This research relies on data collected throughout the period Evolution was active. This data consists of the HTML source code of Evolution pages. Parts of the platform were indeed duplicated between January 2014 and March 2015 (115 times) by an independent researcher, named Gwern. The data used to get an overview of the market – and evaluate the position of Switzerland within this market – were extracted from the raw data resulting from Gwern's crawling. We did not perform any crawling ourselves. Gwern compiled the entire dataset into a single archive file and made it available online via a Reddit forum on March 19th 2015 (data downloaded on April 30th 2015 on https://reddit.com/2zllmv) .

Each time Evolution was scraped, a directory was created, including all source codes structured in subdirectories, i.e. listings (sales proposals), vendor profiles, stores, images and category. Using Python scripts, all drugs related listings were extracted and tagged with a unique identification code. Orange Canvas, a Python-based visual programming software – specifically an add-on to this software, called 'Textable' [27] – was used to search source codes with regular expressions. They were designed to target listings information (i.e. listing title, the category and price of the product, seller username and ranking, shipping country, countries available for shipping and description). Subsequently, the extracted listings were sorted out, as some listings appeared several times due to redundancies in scraped data. Moreover, information such as the number of transactions and feedback were collected for each vendor from their profile pages. The listings' description as well as the vendors' profile descriptions were not systematically analysed, only those related to the illicit drugs ordered for this research were considered. This structured information was analysed and visualised using Microsoft Excel 2013 and R software [28].

2.2 Illicit drugs ordering

2.2.1 Law Dependencies

Since purchasing illicit drugs is prohibited, a legal authorisation was granted by the Attorney General of the Canton de Vaud in order to place illicit drugs orders for academic purpose. Indeed, the Swiss Federal Act on Narcotics and Psychotropic Substances states: "Institutions involved in scientific research may be granted a licence by the relevant cantonal authority to cultivate, acquire, store and use narcotics to the extent required for their own needs." (NarcA, art. 14 al. 2, in force since 1 July 2011).

Marketplace and Type of Illicit Drugs Selection

At the beginning of this study, Agora and Evolution were the two most popular marketplaces regarding the number and diversity of illicit drugs offered and the total number of retailers [11]. Products were purchased on Evolution since Agora required to be sponsored by an active member to be accessed.

In order to compare the results with street market seizures, cannabis related products and cocaine were targeted. They were purchased from the few active Swiss vendors offering for sale cocaine and cannabis products. Indeed, our authorisations specified that the purchases had to be conducted on the Swiss Territory, in other words, bought from a Swiss vendor. Since Evolution search engine included different specifications, such as "ship from" and "ship to" filters, it was possible to target vendors claiming to deliver products from Switzerland to Switzerland.

2.2.2 Obtaining Bitcoins

Bitcoins were obtained through the website LocalBitcoins.com. At the beginning of October 2014, 0.5183 BTC were bought for 200.00 CHF at a rate of 385.88 CHF/BTC. All bitcoins were transferred to an Evolution account specially created for the purchases. At the end of November 2014, the process was repeated to acquire 0.7625 BTC (300.00 CHF) at a rate of 393.45 CHF/BTC) in order to make a second set of purchases.

2.2.3 Shipping Method and Packaging

In this study, physical analysis refers only to the description of the shipping method, packages and concealment techniques of purchased products. This analysis is especially useful to discuss the exactitude of the "ships from" statement and to provide information on the modus operandi of vendors.

2.2.4 Illicit Drugs Chemical Analysis and Profiling

In Western Switzerland, the chemical analysis (qualification, quantitation and chemical profiling) of illicit drug specimens confiscated by police and customs is centralised in our laboratory, hosted by the University of Lausanne (Switzerland).

In particular, cocaine specimens are analysed through gas chromatography-mass spectrometry (GC-MS) using the analytical method validated in our laboratory [29]. For cannabis-related products, qualification is performed by GC-MS while quantification of THC (□9-tetrahydrocannabinol) is carried out with gas chromatography interfaced with a flame ionisation detector (GC-FID) (see Appendix A). Seizures of cannabis-related products are not systematically profiled in our laboratory, since the main objective of the analysis is to discriminate between legal and illegal cannabis. Depending on the country, growing some subspecies of Cannabis sativa for legal utilisations (e.g. production of textile, edible seeds, essential oils, etc.) is authorized, though restricted. A distinction is possible between these plants and the drug-type varieties [30 ; 31].

A deep explanation of the profiling process (e.g. the selection of target compounds, the statistical methods for the comparison of profiles, and the interpretation of outcomes) is out of the scope of this publication. Therefore, interested readers are kindly requested to refer to previous publications [29 ; 32 ; 33].

Chemical (purity, cutting agent, profile based on major and minor alkaloids and chemical class) and physical information (description of the packaging and appearance) information are gathered in a dedicated database since 2006. They result from the analysis of cocaine specimens confiscated by police and customs. Circumstantial information (criminal case number, mass of drugs seized, date and place of the seizure) is also collated [34-36]. In this research work, cocaine specimens purchased on Evolution were profiled and then compared to the profiles stored in this database.

3 Results and discussion

3.1 Overview of the Swiss Market on Evolution

The extraction process applied to the digital data revealed 48'026 different listings offering illicit drugs over the period Evolution was functioning (from January 2014 to March 2015). Table 1 shows the most frequent countries mentioned in the "ship from" field of Evolution listings.

Country of origin	**Listings**	**Percentage**
United States	11,996	24.9%
United Kingdom	5,972	12.4%
Netherlands	4,764	9.9%
Germany	4,579	9.5%
Australia	3,047	6.3%
Canada	2,092	4.3%
Sweden	1,410	3.0%
China	1,142	2.7%
France	949	2.0%
Switzerland	**205**	**0.4%**
Worldwide	**7'939**	**16.5%**
Others	**3931**	**8.1%**

Table 1. Switzerland compared to the top 10 countries of origin mentioned on listings (n=48'026).

Significantly, 16.5% of studied listings do not include any origin information since "Worldwide" is indicated in their "ship from" field. The way countries are listed in that field – namely a structured list of non-misspelled country names – suggests that a pre-filled list of countries is proposed to sellers when creating their listings. A "Worldwide" indication may be explained by a will to hide the true origin of products or a preference for another way to display that information. Indeed, sellers alternatively may give more shipping details in their listing descriptions or on their profile page.

Switzerland stands at the 19th position of the ranking with 205 listings. Regarding destinations toward which illicit drugs may be delivered from Switzerland (see Table 2), around 80% of all listings may be shipped to

Switzerland. Otherwise, only a list of European countries is available. Besides, listings limited by a delivery to Switzerland represent less than 5.9% of all listings.

Destination	**Listings**	**Percentage**
Switzerland only	12	5.9%
Switzerland and a selection of European countries	62	30.2%
Switzerland and rest of the world	91	44.4%
European countries excluding Switzerland	40	19.5%

Table 2. Shipping destinations available for Swiss listings (n = 205).

Thus, Swiss sellers do not appear to be reluctant to send their products across borders, even though it may imply greater risks of detection. We may assume that sellers are very confident about their packaging techniques to avoid detection. Finally, they may accept such a risk of detection at borders because the purchased quantities are generally small. Certainly, they may favour an international expansion of their market, even if it implies refunding a few customers when a shipment is seized [17]. Results provided in Table 2 corroborate this, since listings from around the world are likely to be shipped worldwide rather than to a specific location. This supports the hypothesis that sellers may join a cryptomarket community to expend their distribution area and thus increase their incomes.

Figure 1 shows the distribution of the listings by the drug category according to the terminology used on Evolution.

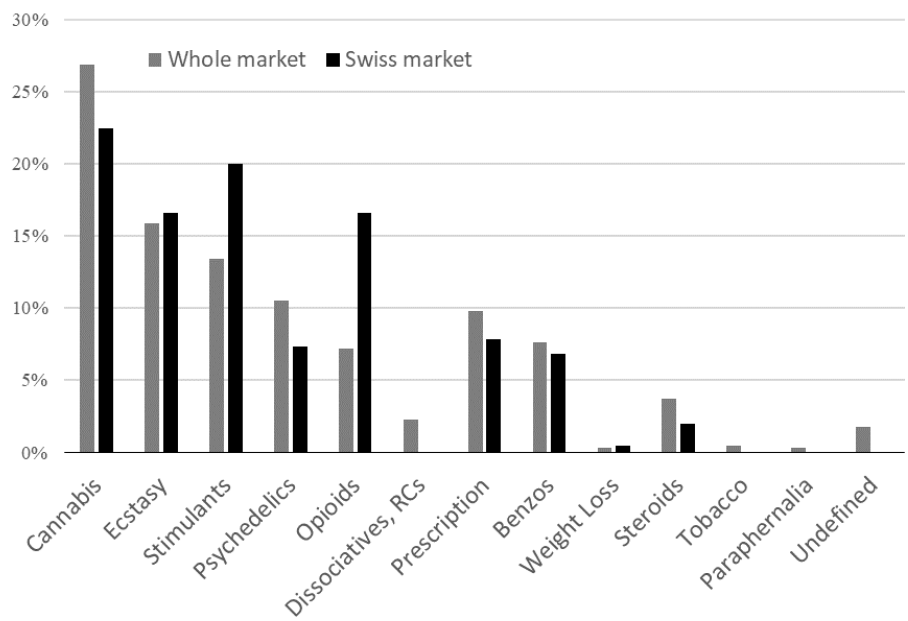

Figure 1. Distribution of the number of listings according to product categories for the whole market (n = 48,026) and Switzerland (n = 205).

More than 25% of the market is about cannabis related products, including marijuana, hashish, seeds, oil and synthetic cannabinoids. Categories such as 'Ecstasy' (MDA, MDMA), 'Stimulants' (cocaine, speed, crystal MDMA) and 'Psychedelics' (LSD, mushrooms) are less represented with 10 to 16% of the listings. To a lesser extent, respectively 7% and 2%, 'Opioids' (heroin, opium) and dissociative products (ketamine, MXE, GHB) are also offered. Prescription drugs such as analgesics or erectile dysfunction treatment were also offered on Evolution, specific categories were created for substances such as benzodiazepines and weight loss products. These medicine products represent almost 18% of all listings while steroids have a proportion fewer than 4%. Tobacco and paraphernalia (i.e. equipment to use drugs) appear to be rather anecdotal categories. Finally, fewer than 2% of listings were not inserted in any category or were classified as 'Other'.

The distribution for the listings marked as shipped from Switzerland is quite similar to the whole market except for products classified as 'Stimulants' and 'Opioids'. In proportion, cannabis is also the largest illicit drug category offered by Swiss sellers. Ecstasy products are still in the three following categories. To the contrary, stimulants and opioids frequencies for the Swiss market – 20.0% and 16.6% respectively – exceed proportions observed in the general distribution.

In regards to the hypothesis that sellers may join the cryptomarket community to expend their distribution area and incomes (see Table 2), the type of illicit drugs sold seems influenced by its accessibility. For example, according to the World Drug Report 2015 [37], Western and Central Europe are among the main destinations of opiates trafficking route originating from Afghanistan, which is the main producer of opiates. This could explain the high proportion of opiates available on the Swiss market. The demand could also explain such differences. To address this question, other indicators – such as the number of vendors or the number of feedbacks of each listing – should be studied. Finally, it seems difficult to explain more precisely the differences observed in Figure 1 without stating to which category each listing truly belongs. Such a classification was not performed in this study, since its purpose was to draw an overview of the Swiss market.

However, the total number of listings with a Swiss origin is quite limited to 205 listings. Furthermore, assessing trends according to the listings' categorisation of Evolution is not without uncertainties. Indeed, misclassifications are possible and some products may fall into several categories (e.g. new psychoactive substances may be classified as 'Stimulants', 'Psychedelics', sub-categories of 'Ecstasy' or 'Dissociatives, RC'). Besides, the number of listings does not equal the number of different products offered on the cryptomarket. Actually, some vendors offer several listings with similar titles except for quantities of product (e.g. 6 listings for 5 to 1000 g of speed paste or 5 listings for 5 to 100 g of cocaine). Aldridge and Décary-Hétu [18] noted the same practice on Silk Road. Such observation could indicate that vendors sell different products, or try to target different kind of customers (i.e. we may assume that consumers would be interested in low quantities for consumption while retailers would source bulk quantities).

3.2 Vendors Information

While some other cryptomarkets only display buyers' feedback, Evolution vendors' profiles also include the number of transactions completed by the corresponding seller. Considering the whole population of sellers offering illicit drugs on Evolution (n = 2,702), the number of transactions per seller is very wide (from 1 to more than 9,000). Thus, among the most prolific sellers, 100 of them concentrate about 40% of all transactions. Besides, it is worth noting that, on average, 62% of the transactions are subjected to some feedback. Such result may help to discuss studies aiming at evaluating vendors' income based on their amount of feedbacks [8 ; 18]. These studies assume that each transaction really occurred, while sellers may generate fictitious transactions to achieve a better ranking or a higher positive feedback rate [14].

Thirteen sellers claim to send products from Switzerland and they offer between 1 and 53 listings. Figure 2 shows the progression of nine Swiss sellers according to their number of completed transactions. For the sake of readability, only those having completed more than 50 transactions are displayed.

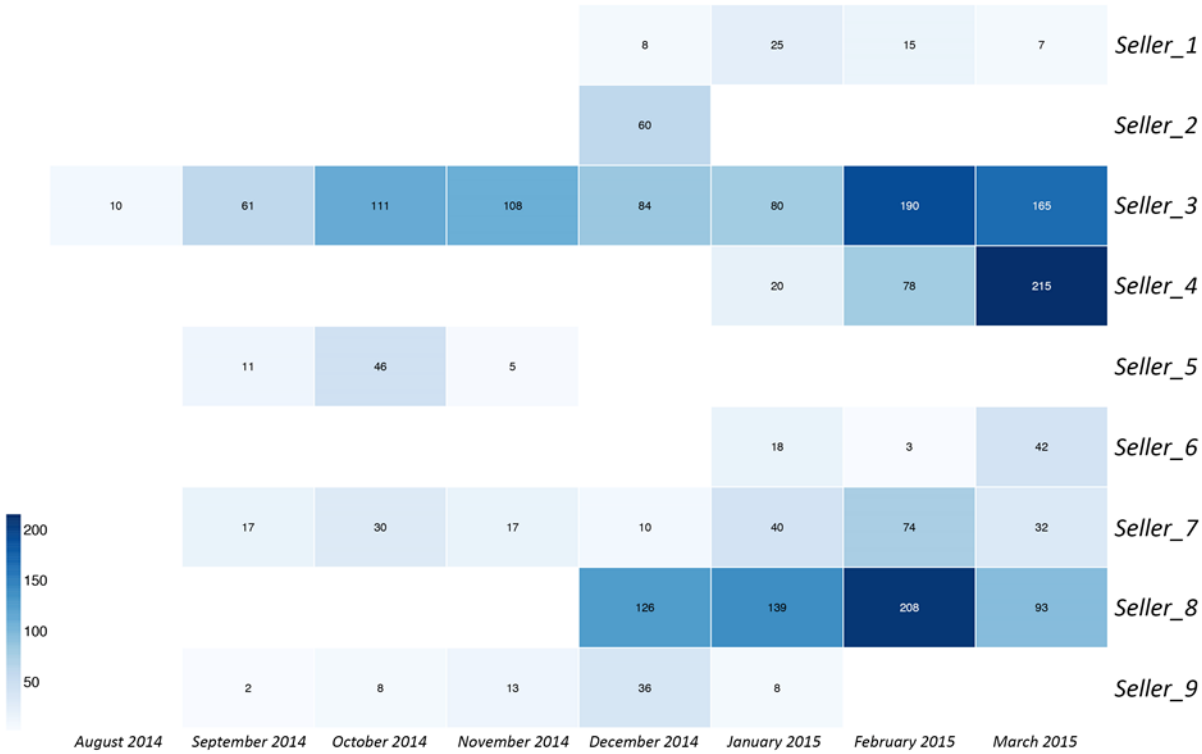

Figure 2. Number of transactions for sellers shipping from Switzerland (with more than 50 transactions) from August 2014 to March 2015.

Swiss sellers started to register on Evolution in June 2014. The first transactions occurred on August 2014. Then, their progression is quite variable, and only four of them completed more than 100 transactions. Besides, these four sellers managed to double their number of transactions (from 100 to 200) over a few months. They may be considered as efficient sellers, exploiting their good reputation. For example, one of them received feedbacks including comments such as “Very Quick delivery. Best quality. Thanks! FE is OK”. Likewise, another seller’s profile page displayed comments about his products and concealment techniques: “hash is definitely of good quality. Shipping was fast, with reliable stealth” or “Excellent product, professional vendor”. It is worth reminding that Operation Onymous took place in late 2014. Since Evolution has not been taken down, sellers with a rather good reputation before the Operation may have benefited from the closing down of other marketplaces. Indeed, only one of them used his previous experience on other marketplaces to advertise his products. This information was displayed on a “legacy sales” page, linked to the seller profile and featured a number of verified transactions on Silk Road, Black Market Reloaded and Agora.

3.3 Online orders

Among the items offered by Swiss sellers, three of them were chosen for purchase – two individual grams of cocaine and one gram of cannabis concentrate (see Table 3). The first item was ordered a second time, after performing the chemical analyses (see further below). For cocaine hydrochloride, price of ordered products are higher than prices encountered on the street market – around 100 USD per gram – in Switzerland, according to UNODC [38]. Similarly, the cannabis concentrate purchased on Evolution is more expensive (around 13 USD per gram on the street market). Beyond the fact that cryptocurrencies such as bitcoin tend to be versatile, price differences may be explained by the selling process on cryptomarkets. Indeed, compared with the street market, the service itself may lead to an increase of the price. From the consumer point of view, buying illicit drugs on a cryptomarket is safer (relative anonymity and no physical contact with the seller) and more discrete due to post delivery. The later could also induce postages fees since packaging material and techniques may be expensive and time consuming. Overall, for customers, high prices are not an obstacle to the purchase of illicit drugs on a cryptomarket. Besides, some researchers noted that consumers may agree to spend more money for illicit drugs bought online, as they expect a better quality consumers [22 ; 39].

Order	Date of order	Date of receipt	Product	Price*
1	14.10.2014	16.10.2014	Cocaine	ca. $135
2	14.10.2014	16.10.2014	Cannabis concentrate	ca. $60
3	27.11.2014	03.12.2014	Cocaine	ca. $110
	not ordered	03.12.2014	MDMA	
4	10.12.2014	12.12.2014	Cocaine	ca. $150

Table 3. Orders details of cocaine and cannabis products. One gram of product was ordered for each purchase.

For the third order, two extra pills were also received, probably as part of a development of customer loyalty strategy. The corresponding vendor was active during a short period of time and only performed a limited number of transactions. Concerning the two other vendors from which purchases were made, one of them left the market shortly after the ordered was placed, while the other was active until Evolution closed.

3.4 Shipping method and packaging analysis

Table 4 summarises the package descriptions, and concealment measures used by vendors to ensure the delivery to the customer. Every illicit drug ordered was sent through the standard Swiss postal services. A Swiss return address with a fictitious name was indicated on one of the sending, most likely to avoid suspicion.

Thus, according to our four purchases, these results confirm the origin claimed by the vendors. In regards to our specimen, the ‘ship from’ digital evidence thus seems reliable information to analyse the market based on the country of origin.

External packaging is a conventional envelope with a “professional looking” as mentioned by Christin [19]. Concealed measures – e.g. vacuum sealing, a static shielding bag – were used by sellers and constitute what is

* Prices converted according to the exchange rate on Evolution index page and rounded to the nearest 5 USD.

referred to as "stealth" methods by Martin [14] (see Appendix B for further illustrations). Indeed, these methods seem obviously used to get through package inspection.

Order	External packaging	Concealment measures
1	Padded envelope in C5 standard format with self-adhesive label including printed receiver address (see Fig. 3).	Heat-sealed static shielding bag containing heat-sealed plastic bag with a Minigrip® bag of the drug product (see Fig 4).
2	Paper envelope in C5 standard format with fake printed sender address (see Fig 5.).	Heat-sealed plastic bag containing the product on blotting paper. Plastic bag taped to a post office sheet of paper (see Fig. 6).
3	Windowed paper envelope in C5 standard format.	DVD keep case containing heat-sealed aluminium plastic laminated bags with a Minigrip® bag of the drug product (see Fig. 7).
4	Padded craft envelope in C5 standard format with self-adhesive label including printed receiver address (see Fig. 8).	Heat-sealed static shielding bag containing heat-sealed plastic bag with a Minigrip® bag of the drug product (see Fig. 9).

Table 4. Packaging descriptions (see Appendix B for Figures 3 to 9).

Overall, information about packaging displayed on the cryptomarket is consistent with the postal shipping we received. For example, some sellers' profile pages include a description of the external packaging – often presented as regular letters – while others focus on concealment techniques (e.g. multiple sealing or special boxing). Thus, the observations made on the packaging are overall in line with the online description. We can infer that sellers explain their real modus operandi to reassure customers that their products have a good chance to reach its destination. Even if our sample is limited, the physical analysis tends to confirm that the description of packaging can be used as a relevant digital evidence to better understand sellers' practices. A systematic analysis of the online descriptions may thus lead to detect and follow the evolution of concealment strategies.

3.5 Chemical Analyses of the Products

Qualitative analyses confirmed the presence of the main psychoactive substance claimed to be sold for each illicit drug purchased on Evolution. In other words, the advertised substance was present in the received samples. Differences were, however, observed regarding the chemical composition. For instance, the purity advertised on the listings always differed from the results of the quantitative analyses. In particular, it was lower for every cocaine specimen (see Table 5). Lastly, composition of the ordered cocaine products did not differ significantly from the cocaine specimen seized by law enforcement authorities in Western Switzerland in terms of purity and cutting agents [34].

After the first set of orders in October-November 2014, a message was sent through the Evolution message handler, to the seller who offered the first item (Order 1). The purpose of this message – stating that the product

quality was not as good as expected – was to assess the influence of such a comment on the seller's marketing decision. No response to this message was ever received. However, since the corresponding listing was still available, a second order was placed for the same product. It turned out to contain a product of similar quality than the first one in terms of purity and cutting agents. The process was not replicated with the other sellers since they were not active on Evolution anymore.

3.6 Chemical profiling of cocaine specimens

Cocaine products ordered in October and November 2014 (Orders 1 and 3) were not associated with any existing chemical classes of our database. They are therefore not linked to any previously analysed cocaine specimen. By contrast, the cocaine product ordered on December 10th (Order 4) was chemically linked to specimens originating from three seizures confiscated in the Canton de Vaud; two seizures were performed in May and September 2014 in Lausanne and one in May 2013 in Vevey. This chemical link based on profiling means that the specimens were once part of the same physical unit before it was broken up for further distribution [35].

Order	Advertised product	Chemical composition		
		Active ingredient	**Average purity**[†]	**Cutting agents**
1	1g of cocaine (≥ 95%)	Cocaine HCl	33.7 ± 0.8%	glucose, levamisole
2	1 g of cannabis concentrate	THC[‡]	49.6 ± 8.3%	N/A
3	1g of cocaine (≥ 85%)	Cocaine HCl	69.0 ± 1.2%	levamisole, phenacetin
		MDMA[§]	26.7 ± 0.2%	palmitic acid, stearic acid
4	1 g of cocaine (≥ 95%)	Cocaine HCl	30.2 ± 0.1%	glucose, inositol, levamisole, phenacetin

Table 5. Results of the chemical analyses on ordered products.

4 General discussion and conclusion

4.1 Ethical considerations and further research

Despite the value of the information obtained through the analysis of illicit drugs bought online, such research raises ethical questions. First, it implies encouraging illicit markets since orders and transactions are actually carried out. Admittedly, quantities purchased are not excessive, but if further research was undertaken, orders would need to be justified and planned to address specific questions. The fact that online purchases found

[†] For cocaine specimen, average purity is calculated for the base form of cocaine.
[‡] Δ^9-tetrahydrocannabinol.
[§] 3,4-methylendioxy-methamphetamine.

illicit activities may restrain the capacity to reproduce the experiment at a larger scale. Besides, as mentioned by Soska and Christin [8] regarding their measurement, our study does not aim to support law enforcement units to arrest sellers. This is the reason why we avoided identifying vendors from which the orders were placed by mentioning their usernames in this article [40]. Finally, cryptomarkets versatility may constitute an obstacle to a longitudinal analysis, especially if the aim is to address questions regarding sellers' activities (e.g. chemical links on a larger scale, stability according to vendors).

4.2 Digital Data Reliability

Crawling cryptomarkets is a challenging step. As mentioned by Dolliver [26], using a web crawler may result in reliability issues. Hence, comparing data obtained through different crawling methods might be difficult, if not possible. Consequently, it is worth reminding that information obtained by exploring this kind of data would only lead to trends. Data is indeed partial, first because the crawling process is not repeated every day or the same number of times each month. Secondly, when the crawling is performed, every single source code file is not necessarily duplicated, as illustrated by the missing listing page for one of the orders. However, using such data allows the estimation of the online prevalence of illicit drugs offers, as well as the number and activity of vendors. The comparison of digital evidence with the results of the physical and chemical analysis performed on purchased products helped to evaluate the reliability of the collected information. Since our number of purchases is limited, our conclusions should, of course, be considered as indicative. Globally, it seems that digital information about the type of product, the country of origin and the concealment techniques used by sellers are accurate. The claimed quality of the products seems, however, less reliable information.

4.3 Perspectives for Forensic and Investigation Purposes

Presently, packages received in this study are made of plastic, paper or adhesive tape. Their forensic analysis may lead to the detection of fingermarks or DNA traces. However, our legal authorization stated that our research aimed only at studying the products sold online by purchasing illicit drugs and performing analyses. Therefore, exploiting DNA traces or fingermarks for investigative purposes was not part of this study. Interestingly, Van Hout and Bingham [20] pointed out, through online interviews of vendors, that many sellers are using latex gloves and masks to avoid leaving fingermarks or DNA traces into or onto packages. The packages of ordered products may lead to the detection of such traces for investigation purposes. Besides, in the frame of an investigation, postal stamp notifies by which mail distribution centre a parcel went through, providing a geographical indication of the region the sender may be located. In a multilingual country like Switzerland, the use of additional material, such as printed paper for the second order (see Appendix B), may provide information about the linguistic region where the seller comes from. Since they appear to be accurate, packaging and concealment techniques descriptions should be more systematically studied. Indeed, they may constitute an interesting lead to detect such packages while they are handled by postal services and customs for international sales.

4.4 Drugs Quality Assessment and Profiling

Studying packaging and chemical results for the three ordered illicit drugs revealed both concordance and discrepancies with what was advertised. As Van Hout and Bingham [20] noted, packaging is an important component of quality assessment. The vendors from whom orders were placed used "stealth" methods consistent with their profile pages. However, it appears not to be essential. Indeed, one of the Swiss sellers turned out to be a rather successful vendor – according to his number of transactions – even though his profile

page did not mention any packaging information. On the other hand, other sellers described meticulously their products – as well as their packaging, concealment techniques and refund process – without achieving a particular success on Evolution. The popularity of a seller appears to be the result of a complex process. Specifically since assessing products quality may be a difficult task for consumers who consequently rely on other aspects such as sellers ranking, packaging, previous comments or product appearances. Thus, as argued by Bancroft and Scott Reid [41], quality takes a whole different meaning within a cryptomarket community than in the chemical sense. Qualitative research also revealed the influence of the information found on marketplaces – or their related forums – on consumers' practices [21 ; 22 ; 39]. The same questions arose regarding illicit drugs sold on the traditional market. Studies have shown the lack of knowledge of Belgian consumers back in the 1990s [42]. While we may assume that online forums facilitated finding information and sharing knowledge about illicit drugs more recently, the situation barely evolved. Indeed, more recently Evrard and al. [43] highlighted that from a user perspective, the perceived quality of the cocaine depends on information provided by the dealer and also on price. These factors continue to affect consumers after use, despite adjustment on the actual cocaine content [43].

The chemical composition (i.e. purity, cutting agents) of cocaine purchased online is similar to specimens confiscated by police and customs in Western Switzerland. It is worth noting that this observation is only representative of cocaine hydrochloride sold from and to Switzerland. Generalising these results to other shipping and destination countries is, so far, impossible. However, despite the limited number of orders, the highlighted chemical links indicate that the products sold online and in the street share similar chemical characteristics. On the one hand, an explanation would be that online sellers buy their products from street dealers. On the other hand, both of them could share the same source of supply. Finally, a last hypothesis would be that cryptomarkets allow street retailers to diversify their distribution channels. Nevertheless, as noted by Martin [14], the limited knowledge of online distribution networks (e.g. online sellers' position in the distribution process) prevents a better assessment of this relationship. A recent study showed, however, that analysing digital data might reveal important actors and distribution networks in Darknet markets [6]. Exploiting chemical information related to products sold on Darknet markets is a developing activity, mainly for harm reduction purposes. [44]. The chemical profiling methodology we applied on the ordered substances provide another perspective about chemical information. It constitutes an interesting tool to study distribution networks, fuel hypotheses about sellers' practices, show relations between traditional and online markets as well as inform on products level within distribution channel.

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6 References

[1] Meyers K, Kaynak Ö, Bresani E, Curtis B, McNamara A, Brownfield K, and al. (2015). The availability and depiction of synthetic cathinones (bath salts) on the Internet: do online suppliers employ features to maximize purchases? International Journal of Drug Policy, 26 (7), 670-4.

[2] Gelatti U, Pedrazzani R, Marcantoni C, Mascaretti S, Repice C, Filippucci L, and al. (2013). 'You've got m@il: fluoxetine coming soon!': accessibility and quality of a prescription drug sold on the web. International Journal of Drug Policy, 24 (5), 392-401.

[3] Aked S, Bolan C, Brand M (2013). Determining what characteristics constitute a Darknet. Proceedings of the 11th Australian Information Security Management Conference. Perth, Australia. 12-20.

[4] AlQahtani A, El-Alfy E (2015). Anonymous connections based on onion routing: A review and a visualization tool. Procedia Computer Science, 52, 121-8.

[5] Zantout B, Haraty R (2011). I2P data communication system. Proceedings of the Tenth International Conference on Networks. Sint Marteen, Netherlands Antilles. 401-9.

[6] Broséus J, Rhumorbarbe D, Mireault C, Ouellette V, Crispino F, Décary-Hétu D (2016). Studying illicit drug trafficking on Darknet markets: structure and organisation from a Canadian perspective. Forensic Science International, 264, 7-14.

[7] Reid F, Harrigan M (2011). An analysis of anonymity in the bitcoin system. Proceedings of the International Conference on Privacy, Security, Risk and Trust (PASSAT) and International Conference on Social Computing (SocialCom). Boston, USA. 1318-26.

[8] Soska K, Christin N (2015). Measuring the longitudinal evolution of the online anonymous marketplace ecosystem. Proceedings of the 24th USENIX Security Symposium. Washington D.C., USA. 33-48.

[9] Böhme R, Christin N, Edelman B, Moore T (2014). Bitcoin: economics, technology, and governance. Journal of Economic Perspectives, 29, Harvard Business School NOM Unit Working Paper No. 15-015. Available at http://ssrn.com/abstract=2495572 (06.04.2016).

[10] Van Buskirk J, Roxburgh A, Bruno R, Burns L (2014). Drugs and the Internet, Issue 2. Available at https://ndarc.med.unsw.edu.au/sites/default/files/ndarc/resources/Drugs&TheInternet_Issue2.pdf

[11] Van Buskirk J, Roxburgh A, Bruno R, Burns L (2015). Drugs and the Internet, Issue 4. Available at https://ndarc.med.unsw.edu.au/sites/default/files/ndarc/resources/Drugs & The Internet Issue 4.pdf (12.01.16).

[12] Tzanetakis M, Kamphausen G, Werse B, von Laufenberg R (2016). The transparency paradox. Building trust, resolving disputes and optimising logistics on conventional and online drugs markets. International Journal of Drug Policy, http://dx.doi.org/10.1016/j.drugpo.2015.12.010 (35), 58-68.

[13] Van Buskirk J, Roxburgh A, Bruno R, Burns L (2015). Drugs and the Internet, Issue 5. Available at https://ndarc.med.unsw.edu.au/sites/default/files/ndarc/resources/Drugs & The Internet Issue 5.pdf (12.01.16).

[14] Martin J (2014). Drugs on the dark net - How cryptomarkets are transforming the global trade in illicit drugs. Basingstoke, UK: Palgrave MacMillan.

[15] UNODC (2014). World Drug Report 2014. United Nations publication, Sales n° E.14.XI.7, 1-51.

[16] Phelps A, Watt A (2014). I shop online – recreationally! Internet anonymity and Silk Road enabling drug use in Australia. Digital Investigation, 11 (4), 261-72.

[17] Martin J (2014). Lost on the Silk Road: Online drug distribution and the 'cryptomarket'. Criminology & Criminal Justice, 14 (3), 351-67.

[18] Aldridge J, Décary-Hétu D (2014). Not an 'eBay for drugs': the cryptomarket "Silk Road" as a paradigm shifting criminal innovation. Social Science Research Network. Available at http://ssrn.com/abstract=2436643 (12.01.16).

[19] Christin N (2013). Traveling the Silk Road: a measurement analysis of a large anonymous online marketplace. Proceedings of the 22nd International World Wide Web Conference. Rio de Janeiro, Brazil. 213-24.

[20] Van Hout MC, Bingham T (2014). Responsible vendors, intelligent consumers: Silk Road, the online revolution in drug trading. International Journal of Drug Policy, 25 (2), 183-9.

[21] Van Hout MC, Bingham T (2013). 'Silk Road', the virtual drug marketplace: A single case study of user experiences. International Journal of Drug Policy, 24 (5), 385-91.

[22] Van Hout MC, Bingham T (2013). 'Surfing the Silk Road': A study of users' experiences. International Journal of Drug Policy, 24 (6), 524-9.

[23] Dolliver DS (2015). Evaluating drug trafficking on the Tor Network: Silk Road 2, the sequel. International Journal of Drug Policy, 26 (11), 1113-23.

[24] 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), 1124-5.

[25] Van Buskirk J, Roxburgh A, Naicker S, Burns L (2015). A response to Dolliver's “Evaluating drug trafficking on the Tor network”. International Journal of Drug Policy, 26 (11), 1126-7.

[26] Dolliver DS (2015). A rejoinder to authors: Data collection on Tor. International Journal of Drug Policy, 26 (11), 1128-9.

[27] Xanthos A (2014). Textable: programmation visuelle pour l’analyse de données textuelles. Proceedings of the 12th international Conference on Textual Data statistical Analysis. Paris, France. 691-703.

[28] R Core Team (2015). R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Available at https://www.R-project.org.

[29] Esseiva P, Gaste L, Alvarez D, Anglada F (2011). Illicit drug profiling, reflection on statistical comparisons. Forensic Science International, 207 (1-3), 27-34.

[30] Broséus J, Anglada F, Esseiva P (2010). The differentiation of fibre- and drug type Cannabis seedlings by gas chromatography/mass spectrometry and chemometric tools. Forensic Science International, 200 (1–3), 87-92.

[31] Broséus J, Vallat M, Esseiva P (2011). Multi-class differentiation of cannabis seedlings in a forensic context. Chemometrics and Intelligent Laboratory Systems, 107 (2), 343-50.

[32] Esseiva P, Ioset S, Anglada F, Gasté L, Ribaux O, Margot P, and al. (2007). Forensic drug Intelligence: An important tool in law enforcement. Forensic Science International, 167 (2-3), 247-54.

[33] Ioset S, Esseiva P, Ribaux O, Weyermann C, Anglada F, Lociciro S, and al. (2005). Establishment of an operational system for drug profiling: a Swiss experience. Bulletin on narcotics of United Nations Office on Drugs and Crime, 57 (1-2), 121-47.

[34] Broséus J, Gentile N, Bonadio Pont F, Garcia Gongora JM, Gasté L, Esseiva P (2015). Qualitative, quantitative and temporal study of cutting agents for cocaine and heroin over 9 years. Forensic Science International, 257, 307-13.

[35] Broséus J, Huhtala S, Esseiva P (2015). First systematic chemical profiling of cocaine police seizures in Finland in the framework of an intelligence-led approach. Forensic Science International, 251, 87-94.

[36] Broséus J, Baechler S, Gaste L, Bonadio Pont F, Garcia Gongora JM, Gentile G, and al. (2016). Chemical Profiling: a tool to decipher the structure and organisation of illicit drugs markets. An 8-year study in Western Switzerland. Forensic Science International, 266, 18-28.

[37] UNODC (2015). World Drug Report 2015. United Nations publication, Sales n° E.15.XI.6, 41-56.

[38] UNODC. UNODC Statistics - Drug prices repoort (cocaine-type in Switzerland). https://data.unodc.org/. 2012.

[39] Barratt MJ, Ferris JA, Winstock AR (2014). Use of Silk Road, the online drug marketplace, in the United Kingdom, Australia and the United States. Addiction, 109 (5), 774-83.

[40] Markham A, Buchanan E (2012). Ethical decision-making and Internet research - recommendations from the AoIR Ethics Working Committee. Association of Internet Researchers. Available at http://www.aoir.org/reports/ethics2.pdf (12.01.16).

[41] Bancroft A, Scott Reid P (2016). Concepts of illicit drug quality among darknet market users: Purity, embodied experience, craft and chemical knowledge. International Journal of Drug Policy, 35, 42-9.

[42] Decorte T (2001). Quality control by cocaine users: Underdeveloped harm reduction strategies. European Addiction Research, 7 (4), 161-75.

[43] Evrard I, Legleye S, Cadet-Taïrou A (2010). Composition, purity and perceived quality of street cocaine in France. International Journal of Drug Policy, 21 (5), 399-406.

[44] Caudevilla F (2016). The emergence of deep web marketplaces: a health perspective. The internet and drugs market (European Monitoring Center for Drugs and Drug Addiction). Luxembourg: Publications Office of the European Union.

Appendix

Appendix A

6.1.1 GC-FID analysis methods

	Cannabis analysis	**MDMA analysis**
Instrument	GC Agilent 7891A	GC Agilent 7891A
Column	Agilent 19091s-101: 1 HP-5MS 20m x 200µm x 0.33µm	Agilent 19091S-101: 1 HP-5MS 20m x 200µm x 0.33µm
Injection	Split 68:1 at 250°C	Splitless at 250°C
Carrier gas	Helium	Helium
Temperature	100°C for 0 min 60°C/min to 280°C for 3 min	70°C for 0.203 min 39.465°C/min to 300°C for 2.027 min
Run time	6 min	8.0579 min
Detector	Flame ionisation detector	Flame ionisation detector
Heater	300°C	300°C
H_2 flow	30 mL/min	30 mL/min
Air flow	400 mL/min	400 mL/min
Makeup flow	22 mL/min	24.028 mL/min

Appendix B

6.1.2 Order 1 – Cocaine hydrochloride – Seller_7

Figure 4. External packaging

Figure 5. Internal parcel containing cocaine hydrochloride in different bags

6.1.3 Order 2 – Cannabis concentrate – Seller_5

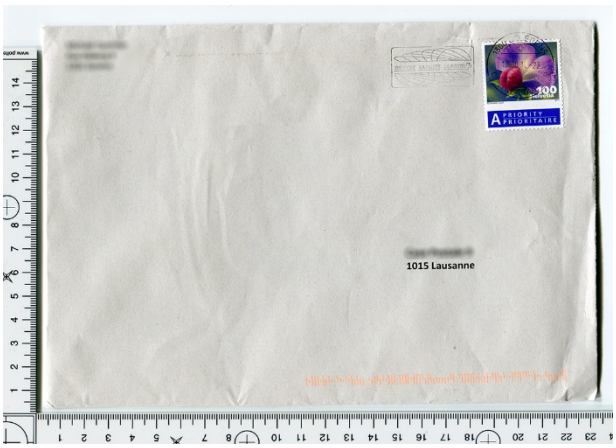

Figure 6. External packaging

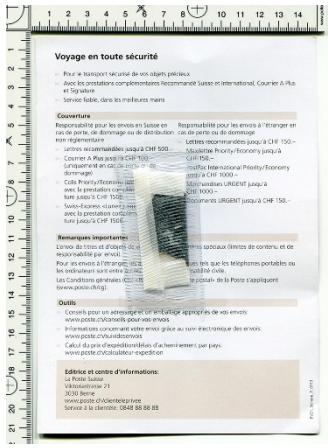

Figure 7. Internal parcel containing cannabis concentrate taped on a piece of paper

6.1.4 Order 3 – Cocaine hydrochloride – Seller_10

Figure 8. DVD keep case containing cocaine and MDMA pills in two different bags

6.1.5 Order 4 – Cocaine hydrochloride – Seller_7

Figure 9. External packaging

Figure 10. Internal parcel containing cocaine hydrochloride in different bags