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# A Market in Dream: the Rapid Development of Anonymous Cybercrime

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**Abstract**

In this paper we have conducted a comprehensive measurement and analysis on the Dream market, an anonymous online market that uses cryptocurrency as transaction currency. We first collect data between October 30th 2018 and March 1st 2019. Then we use decision tree-based approach to classify goods. Following we analyze the category of goods sold in the market, the shipping place of vendors. By analyzing more than 1,970,303 items, we find the goods sold in Dream Market are mainly drugs and digital goods. We estimate the total sales of all vendors, and find that an average monthly income is $14 million during the measurement period, which means that the market commission income is more than $560,000 per month. Based on these data, we use transaction cost theory to analyze the transaction attributes of illegal transactions, which shows that anonymous online market can reduce transaction cost of illegal transactions. We finally discuss the results analyzed and the intervention policy, as well as recent DDoS attacks and future trends of illegal transactions in anonymous online market.

**Keywords** Anonymous online market · Illegal transactions · Cybercrime

## 1 Introduction

Anonymous network initially served as an approach for browsing Internet anonymously, protecting user privacy. With the development of anonymous network, more and more users can access it by related tools such as Tor browser [11] easily. Anonymous online markets that based on it allow buyers and vendors to hide their identity, making it difficult for law enforcement to tracking them. As a result, many prohibited goods such as drugs and privacy data, have become the main business in anonymous online market.

Since the rise of Silk Road in 2011,[1] market size and volume of the anonymous market have been growing. In 2012, the largest anonymous online market items volume was around 24,400 [10]. By 2015, AlphaBay replaced Silk Road and became the largest market. In July 2017, AlphaBay had more than 369,000 products and 400,000 users [1].

Nowadays, three major large anonymous online markets are Dream Market, Wall Street[2] and Silk Road 3.1[3]. Among them, the amount of items daily in Dream Market is around 170,000, which is much more than Wall Street's 10,000. In many dark market forums, Dream Market's score is much higher than the other two [4].

In this paper, we attempt to provide a scientific analysis of Dream Market and anonymous cybercrime by collecting and analyzing a set of data for approximately four months (from October 30th, 2018 to March 1st, 2019). We think our research has mainly four contributions.

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[1] https://en.wikipedia.org/wiki/Silk_Road_(marketplace)

[2] http://wallst4qihu6lvsa.onion/

[3] http://silkroad7rn2puhj.onion/

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(1) We have designed a relatively sophisticated collection system to get public data from Dream Market.
(2) We use collected data to show the groups of goods and vendors in Dream Market.
(3) We use buyer's feedback as a proxy for sales, and we describe the amount of sales in our measurement range. We provide an estimation of daily sales in Dream Market and use this to estimate the amount of commission charged by the market operator. Although we can't use the data sets we collect to estimate the number of buyers, we can see that Dream Market is a very important market with nearly 10 thousand vendors and the average sales is $14 million per month.
(4) We use transaction cost theory to explain the reasons for the continued growth of anonymous cybercrime. We also notice that anonymous cybercrime has been developing rapidly.

The rest of the paper is organized as follows. We give an overview in Section 2. We introduce how we collect data in Section 3 and illustrate our metrics analysis in Section 4, including volume analysis of illegal goods. In Section 5, we discuss market economic data. In Section 6, we use transaction cost theory to explain the reasons for the continued growth of anonymous cybercrime. We discuss our findings in Section 7, including relevant intervention policies and ethical considerations, and discuss related cybercrime, and the impact of DDoS attacks on the market. The related work is outlined in Section 8 and we give our conclusion in Section 9.

## 2 Overview

Dream Market (Fig. 1) is an anonymous online market first appeared in November 2013. There are goods such as drugs, theft data and hacking services in this market. Based on the characteristics of anonymous itself, both buyers and vendors in Dream Market are anonymous. In this section, we summarize the main features of Dream Market by visiting steps involved in a typical transaction and other market mechanisms: access to Dream Market, shopping, and so on.

Similar to other darknet sites, before entering Dream Market, user needs to access the market page by Tor browser. User needs to register her own account in Dream Market. Dream Market supports automatic generation of user names, of course, you can set it yourself. Registration only requires information like username, password, PIN and CAPTCHA. For security reasons, the market supports two login types: password login and 2FA login. 2FA login requires user to set a PGP public key. Only users who have the corresponding private key can log in 2FA.

During transaction, Dream Market charges a certain amount of commission from vendors and imposes restrictions on vendors. Some categories of goods are listed below [3].

– Assassinations or any other services which are doing harm to another.
– Weapons of mass destruction: chemical, biological, explosives, etc.
– Fentanyl.

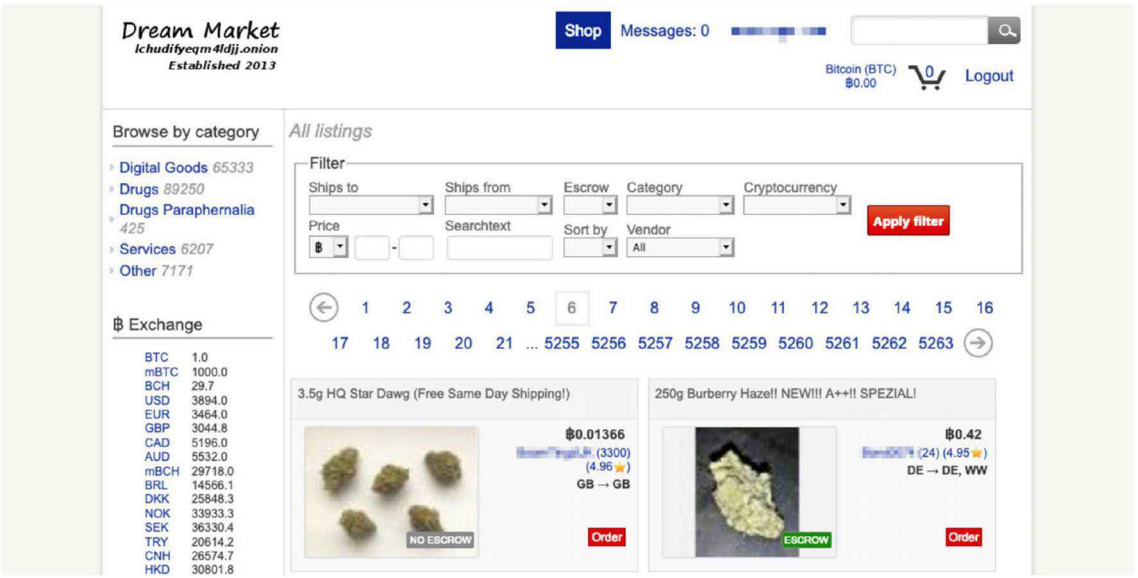


**Fig. 1** Dream Market front page

- Weapons.
- Poisons.
- Child pornography.
- Live action snuff/hurt/murder audio/video/images.

Although the market has restrictions on goods and services such as weapons and violence, sensitive goods such as drugs, fake identity documents (such as fake passports), privacy data and hacking services are still missing from the list of prohibited items.

When user selects a favorite item from the product list, she can click on the item link to make a purchase. The market supports cryptocurrencies such as BTC and BCH, and the wallet address is provided by the market. Before purchasing, user needs to buy or transfer a certain amount of cryptocurrency to the wallet address. Once the wallet has sufficient currency, user can select the transaction currency and set transaction information, then pay for the transaction. Dream Market supports escrow, which means that buyer's payment will not be sent to the vendor immediately. Instead, it first will be escrowed by the market itself, then transfer to vendor after buyer receives the goods and confirms.

After receiving the goods, buyer can give a feedback. Dream Market recommends submitting negative feedback to better solve the vendor's service problems. At the same time, Dream Market provides reporting capabilities, so buyers can report vendor's situation to Dream Market, including receiving problems, fraud and even reporting to the vendor ID which controlled by law enforcement.

## 3 Data collection

In this section we will introduce our data collection methods. We adopt a more secure crawling method, but we have also encountered many challenges. We will illustrate the solve methods below.

### 3.1 Crawling method

We registered our Dream Market account at the beginning of August 2018 and conducted a simple crawl test. We found that Dream Market login page relied on authentication cookie. The cookie was valid for one week. By using this cookie we can re-login without authentication. So we used the cookie as credentials to keep login status.

We used Python Selenium library[4] and corresponding Firefox drivers to simulate real user's behavior and tried to crawl Dream Market. In order to simulate login process as much as possible, we registered different accounts for website login. For each page request, the crawler replaced the circuit once, and we used the stem[5] tool to do this. From October 30th, 2018 to March 1st, 2019, we tried to crawl pages from Dream Market every day and record the time each page crawled.

### 3.2 Challenges

Hiding trace is important during crawling. So, we used Selenium to simulate browser and visited the web cautiously. However, in our initial attempts, we found that if we visited the pages a bit more frequently, it would trigger the anti-DDoS mechanism, which made crawling impossible. In order to solve this problem, we limited our crawl frequency and periodically performed circuit replacement.

In order to enhance the hidden effect, the crawler's threads login use different accounts. We started crawling thread at random time every day. For example, in the adjacent two days, we crawled at 5am and 2pm respectively.

Once login successfully, cookies for Dream Market are valid for one week. But if we do not operate the browser for a period of time, the cookie will expire. In many cases, e.g., when we start crawling every day or because it costs too long to visit pages due to network delay, we need to use a new cookie. Since the website login page needs to enter CAPTCHA, we manually login to get the cookie in the early stage. This is also practical in many previous work [21]. Later, we analyze the patterns of the website's CAPTCHA and develop a machine learning tool based on GAN to achieve automatic login. The CAPTCHA detection can reach higher than 90% accuracy rate. Thereby it can solve the problem of manual login and can do re-login when page-loading timeout.

Although we have made great efforts in hiding trace, we still need to dispose unexpected exceptions. For example, in the middle of January, we received poor quality data due to network failures. These data lacked a lot of information. At the end of January 2019, an organizations began DDoS attacks to Dream Market. Worse in February, it made Dream Market out of visiting during part of February, so the crawler could not obtain valuable data. The attack eased on February 24th and we retrieved data again.

### 3.3 Data sample collection

In the process of crawling, we set a specific regular expression to match the URL of the site, preventing to visit irrelevant URLs. Most pages we crawled are item pages.

[4] https://www.seleniumhq.org/

[5] https://stem.torproject.org/

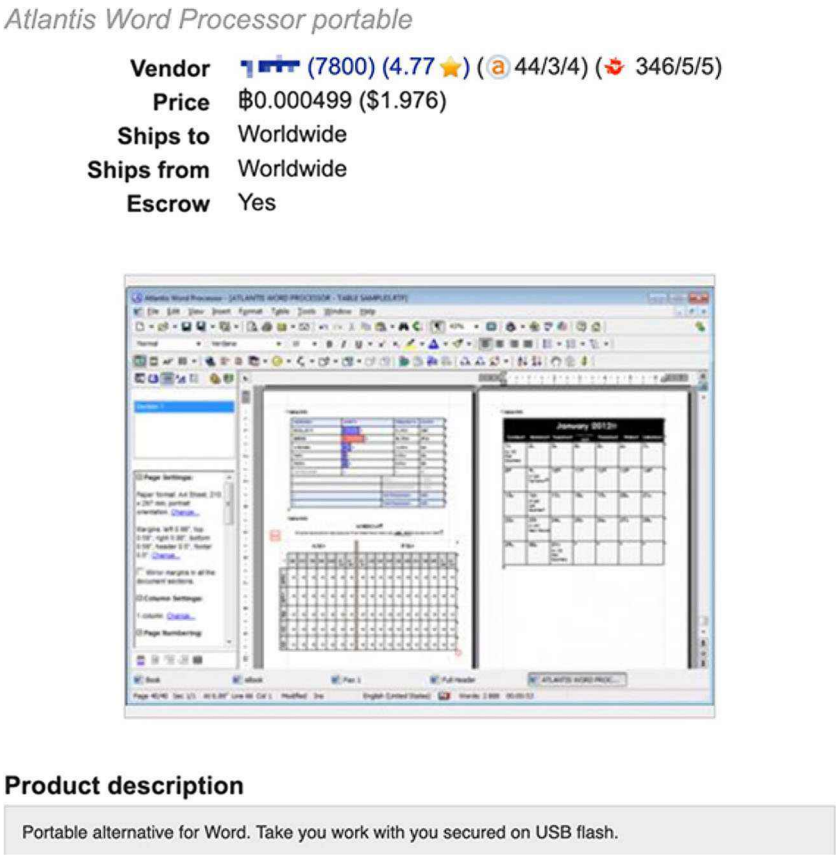


**Fig. 2** Dream Market item page. Each item page contains information such as vendor, price and shipping information

Figures 2 and 3 show an example of a item. The information we collected mainly includes: item name (such as "Atlantis Word Processor portable" in this example), price, ships to/from, item category, item description, buyer feedback (as shown in Fig. 3) and vendor related information (vendor name, sales volume and account verification). This information is publicly available in the market, that means the data we collected does not include buyer's information because the buyer data is not publicly available.

## 4 Market analysis

In this section, we first analyze the goods in this market and their vendors. Then we discuss goods categories.


**Fig. 3** Dream Market buyer feedback

### 4.1 Goods analysis

There are five main categories of goods in Dream Market: digital goods, drugs, drug paraphernalia, services and others. Among them, the largest proportion are drugs and digital goods. Drugs can account for almost half of the goods while digital goods account for about 40%. During our measurement period, approximately 1,970,303 separate items were observed.

From the daily volume, some categories of items occupy most of the market share, that is, the items in Dream Market are mainly concentrated on certain categories, and other items are distributed in more than 90 sub-categories, including some without classification labels. The left sub-figure in Fig. 4 shows the long tail phenomenon in Dream Market. At the same time, we calculated the proportion of each category and showed in the right sub-figure of Fig. 4. We find that about 60% of the items belong to the top 15 categories.

Table 1 shows the top 15 item categories that we sort by the three-level classification provided by the website. Here we separate the sub-categories according to the parent categories. As we expect, these commodities are mainly

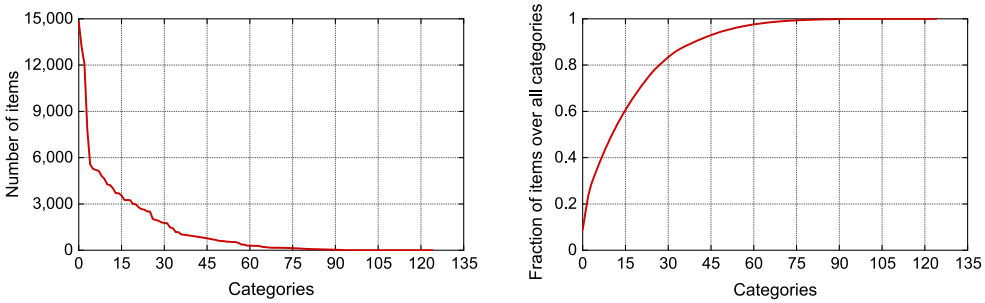


**Fig. 4** Distribution of items per category. The left side shows the number of items sorted by popularity for each category, and the right side shows the cumulative allocation of all items by each category

drugs and digital goods. We found that 10 out of 15 categories belong to drug, and one third of them are cannabis (like hash and weed). Other drugs include LSD, steroids and other restricted drugs; the other five categories include digital goods such as fraud and accounts.

## 4.2 Vendor analysis

We cannot determine the true identity of each vendor due to the anonymity of the market. As a result, we distinguish vendors by their IDs and have observed nearly 40,000 vendors during the measurement period. The left sub-figure of Fig. 5 shows the relationship between the proportion of items and the number of vendors in Dream Market.

We collected the volume of transactions that were successfully traded in the market and shown the result in right sub-figure of Fig. 5. From this figure we can see that the largest number of vendors have about 64,500 successful transactions. We can see the huge gap between top-ranked and lower-ranked vendors. This reflects the huge difference in the popularity of goods in the market.

We speculate that vendors with lower transaction rankings may exit from market earlier than others. We used Kaplan-Meier estimator [15] to compute the survival curve of the probability $T(n)$ of vendor's activity in the market for at least n days during the measurement. In this measurement, we did not use the time the vendor registered because we only want to survey the life period during our measurement. We record the first occurrence and the last occurrence of each vendor during the measurement and show the result in Fig. 6, the confidence for $T(n)$ is 95%. From this figure we can see that most vendors have an average live time of 80 days, and only a few vendors can live more than 120 days.

**Table 1** Top 15 categories in terms of items available

| Category | Sub-category | Percentage |
|---|---|---|
| Digital Goods | E-Books | 8.8% |
| Drugs | Weed | 7.8% |
| Digital Goods | Guides | 7.2% |
| Drugs | Cocaine | 4.6% |
| Digital Goods | Accounts | 3.3% |
| Drugs | Hash | 3.1% |
| Drugs | MDMA | 3.1% |
| Drugs | Pills | 3.1% |
| Digital Goods | Fraud | 2.9% |
| Digital Goods | Digital Goods | 2.8% |
| Drugs | Concentrates | 2.5% |
| Drugs | Steroids | 2.5% |
| Drugs | Benzos | 2.4% |
| Drugs | LSD | 2.2% |
| Drugs | Cannabis | 2.2% |

About verifying vendor account, Dream Market provides vendors with an account verification mechanism, and vendors can verify their accounts in other markets and reference their own evaluation information from other markets. Dream Market mainly supports account verification among 11 markets include Alphabay and Nucleus. Dream Market also provides "Trusted seller" labels for high-credit vendors. We have compiled statistics on the account verification of vendors during the measurement period. Table 2 shows the top 8 account verification information. Most vendors do not have account verification information. The account verification that the information source is mainly Alphabay, Agora and Hansa which have once flourished in the large-scale anonymous online market. Research by Wegberg and Verburgh [23] showed that after Alphabay and Hansa were closed in the Operation Bayonet in July 2017, a large number of users poured into the Dream Market, which should including these vendors.

We compare the vendor's account verification data with the transaction data and draw the relationship lines in Fig. 7. We can see that although the vendor's transaction volume has some irregular fluctuations as the vendor's account verification decreases, the overall trend is consistent with the verification, which confirms our speculation that the vendor's credit has a large impact on the vendor's transaction [12].

Next, we checked the shipping information for all items, mainly including origin and destination. Table 3 shows the top 8 locations where the goods are shipped from and the destination is the overall proportion, with most of the goods are received worldwide. In addition, most of the places of receipt are mainly concentrated in Europe, United

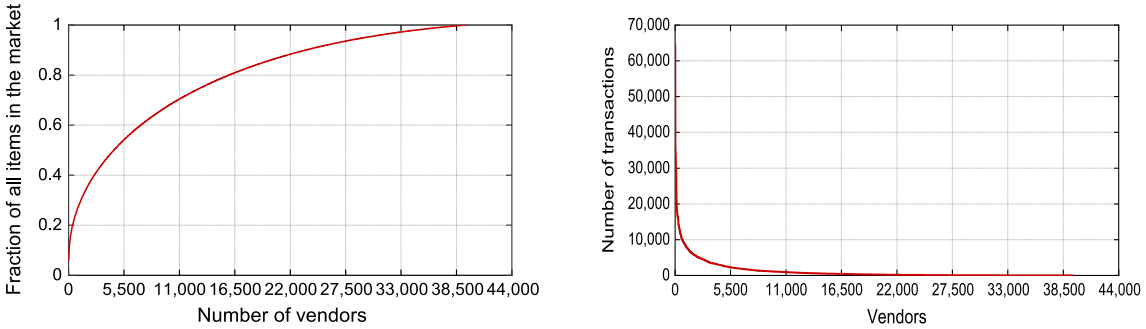


**Fig. 5** The left side shows proportion of items in the market as a function of the number of vendors, and the right side shows the number of transactions of vendors

States and Canada. It can be seen that darknet trafficking overcomes the challenge of vendors and customers having to be in the same location [6], allowing items to be transported worldwide.

In terms of origin, since Dream Market allows vendors to freely fill in the origin information when publishing items, in this respect, compared with the destination, the vendor's setting of the origin is very irregular, and different vendors have different ways of describing the same location. However, we can still see that the origin of goods is mainly concentrated in the United Kingdom, Germany, Netherlands and other European countries as well as the relatively developed countries such as United States and China. It is worth noting that some vendors have a certain spelling error in the origin, such as "Gemrmany", "unoted states", etc. However, we believe that this may be intentional by the vendor and is intended to confuse the review of law enforcement. At the same time, we also noticed that some of the fillings is not like the origin, but it is more like a supplement to the destination, such as "usa2usa&india2uk", which aims to explain the relationship between the origin and the destination; "ww except us", this filling is more like an destination description. This reflects the vendor's sensitivity to the origin, and some vendors are reluctant to publish their origin of goods in the market, which is also a way to deal with law enforcement review.

Dream Market provides escrow. During our measurement period, the market requires that the items published by the vendor must be subjected to escrow, that is, the payment is managed by the market before the buyer confirms the receipt. However, we found that not all items have escrow. In our measurement, we find that 85.12% of the items have escrow, and about 14.88% of the items no escrow.

## 4.3 Categories

Next, we consider the classification of the goods. Figure 8 shows the distribution of the five categories of goods in the Dream Market. We can see that the main goods sold by Dream Market are drugs and digital goods. Since the market allows the classification of goods to be empty, and the classification options provided by the market for vendors are relatively chaotic, such as the subordinate inclusion relationship, we designed a machine learning classifier and re-identified.

Since description information of the good is described by the data type of the string, we extracted the feature as the input of the classifier. We identified and extracted 76,858 descriptions with different item of accurate labels as corpus,

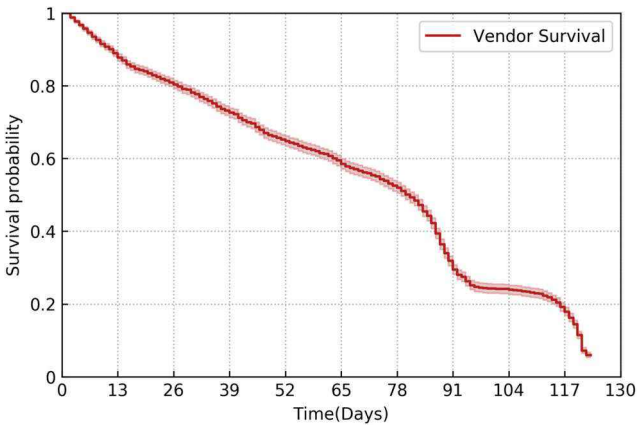


**Fig. 6** Probability a vendor will continue selling goods on the market as a function of time (in days)

**Table 2** Top 8 markets of verification(include Dream market's trusted)

| Category | Percentage |
|---|---|
| None | 72.6% |
| Alphabay | 12.9% |
| Not advanced to trusted seller | 6.8% |
| Agora | 3.9% |
| Nucleus | 3.0% |
| Trusted seller | 2.7% |
| Hansa | 2.7% |
| Abraxas | 1.3% |

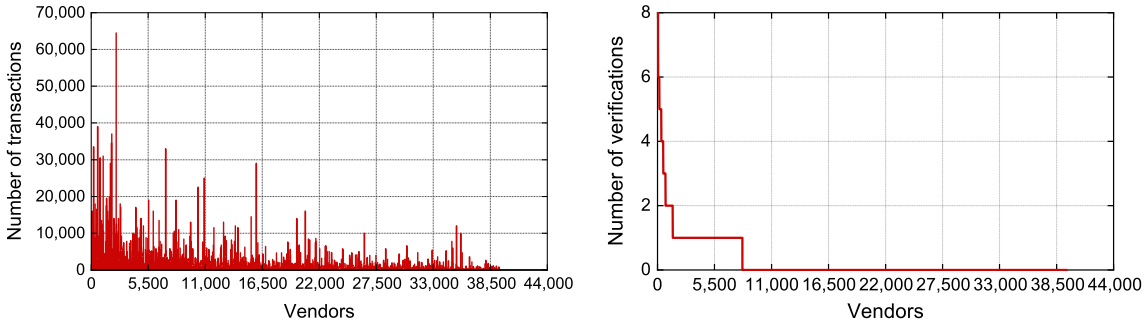


**Fig. 7** Transactions and verifications of vendors

and selected 5,317 non-stop words with frequency more than 0.002 as feature words. We calculated the tf-idf values corresponding to the above characteristic words of 76,858 samples.

In order to increase the training speed of the classifier, we perform the unsupervised feature selection by principal component analysis (PCA). The first 3246 principal components after PCA explain the variance of 95%. We use this as the 3246 feature input of the classifier. Since the number distribution of the five major categories of drugs, digital goods, other, services and drugs paraphernalia in the sample is extremely uneven (about 40:30:5:3:0.3), we choose the decision tree which has a less sensitive in the case of uneven sample distribution as classifier and use the gradient boosting decision tree which in the LightGBM framework[6]. We divided the samples into training, validation, and test sets in a 6:1:3 ratio. After multiple parameter adjustments on the training set and the verification set, the accuracy of the classifier on the test set can reach 95%. Metric during training as shown in Fig. 9.

After the classification, we found that the distribution of independent good categories during the measurement was basically the same as the daily distribution of goods in the market. We collected and analyzed the origin and destination of each type of good, and we find that the transaction scope of drug-based goods is mainly concentrated in North America, Europe and Asia; digital goods and services are based on the special nature of online shipments, and their transaction scope covers the whole world.

## 5 Economic analysis

In this section we will discuss the economic indicators of Dream Market. We first estimate the transaction volume of the market, then calculate the average price of goods in each category based on the classification in Section 4.

[6]https://github.com/Microsoft/LightGBM

### 5.1 Sales

As described in Section 3, we obtained feedback on items in the market during the measurement period and used the feedback information as a indicator to calculate recent transaction volume. Considering the comprehensiveness of the feedback information collected, there may be cases such as buyer deleted original feedback information or reposted feedback during our measurement. Therefore, using feedback information directly is not correct. We refer to the Christin's method [10] by using the average value in a 30-day sliding window, trying to estimate the daily sale volume. This method can eliminate potential problems caused by updating feedback. We limited the time window to 30 days because the average number of days we measured for 4 months is exactly 30 days.

The results of our estimation are shown in the left side of Fig. 10, where each point corresponds to the average daily volume of the past 30 days. For each goods, the total volume is calculated by counting the amount of feedback the buyer posted in the past 30 days and multiply this number by the average price over the past 30 days. The daily transaction volume can be estimated as the final transaction volume divided by 30.

We can see that the sales volume in December is significantly higher than that in January, which may due to

**Table 3** Top 8 most frequent shipping to(left), and shipping from(right)

| Ship to | Pct. | Ship from | Pct. |
|---|---|---|---|
| Worldwide | 60.79% | Worldwide | 17.86% |
| Europe | 23.95% | United States | 17.59% |
| United States | 16.88% | United Kingdom | 14.85% |
| United Kingdom | 12.31% | Germany | 7.28% |
| Australia | 4.55% | Netherlands | 5.69% |
| Germany | 2.67% | Europe | 5.24% |
| Sweden | 2.26% | Australia | 3.07% |
| Canada | 1.39% | Sweden | 2.88% |

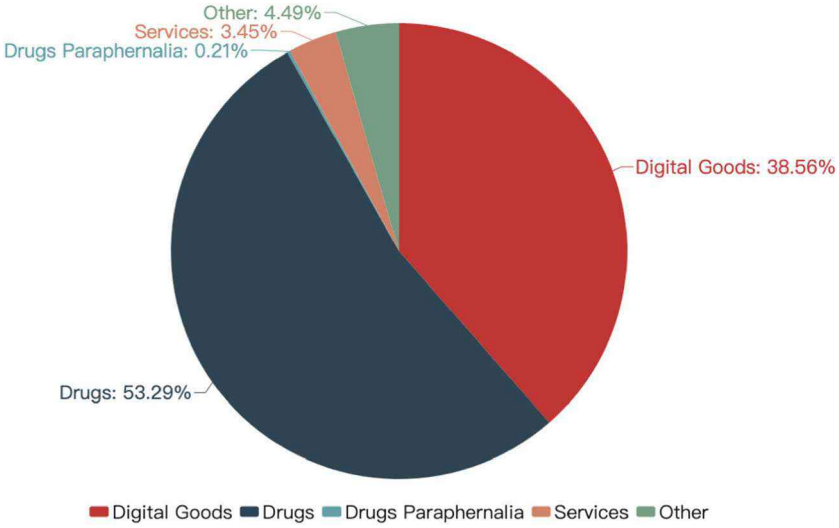


**Fig. 8** Main categories

the climax of shopping at this special time period, the end of the year. We plot the curve of 1 Bitcoin corresponding to the four physical currencies during the measurement period. As shown in the right side of Fig. 10, we can observe that the sales volume rise as the exchange rate decreases. This is consistent with the market phenomenon we observed, that is, the market price of Dream Market will be adjusted with the exchange rate to ensure its price stability to the physical currency.

In particular, we should note that after we resumed data acquisition at the end of February, although the exchange rate increased slightly from the end of January, this was not enough to cause the sales volume to decrease so much during this period. This decline in sales should be due to the DDoS attacks on the site. Regarding the DDoS attacks that began at the end of January, users in a Darknet Forum [4] have different opinions. We will discuss this in Section 7.

We use the exchange rate on the right side of Fig. 10 to convert sales to US dollars, and find that during our measurement period, the average monthly sales volume is at least $14 million. Since the market sales volume in February was affected by DDoS, that is, the annual sales volume of the entire market will generally exceed $200 million. At the same time, the market will charge 4% of the vendor's sales as a market commission, so that Dream Market's annual income is about $8 million.

## 5.2 Price of classified goods

As described in Section 4.3, we designed a machine learning classifier to reclassify goods. We calculated the average price of each category of goods. The average price of drugs is $1059.91. Here, since the market does not distinguish between the sales patterns, the average price is not differentiated between retail drugs and wholesale drugs. According to the data provided by the UNODC [6], we find the average price we get is between the lowest retail price and the highest wholesale price, which indicates that the price of drugs in Dream Market is basically the same as in other drug selling channels.

On the other hand, we found the average price of digital goods was the lowest, only $156.14. We notice that digital goods in Dream Market mainly include e-books and information. This low-priced sale will seriously infringe the intellectual property rights of the authors of the books and the privacy rights of the people related in the information.

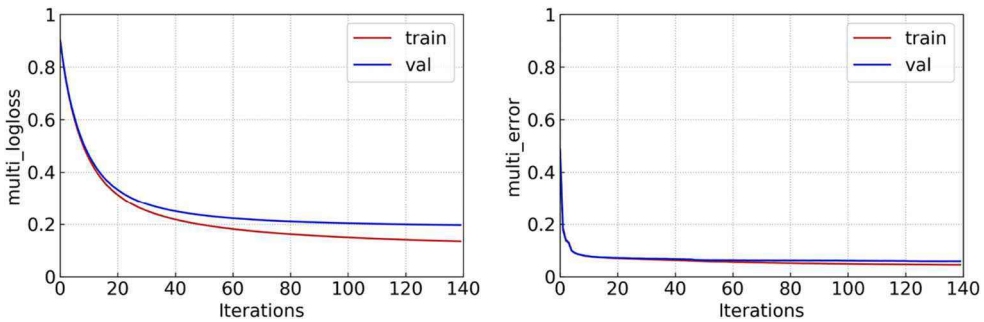


**Fig. 9** Metric during training

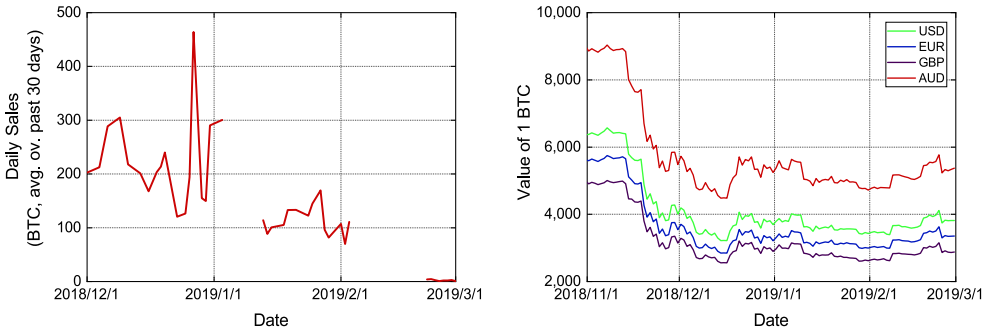


**Fig. 10** Estimate of the total amount of daily sales (in BTC) occurring on Dream Market(left) and evolution of the value of a Bitcoin in the four major currencies used in the countries of the vendors operating on Dream Market(right). Data is from CoinGecko [2]

## 6 Transaction cost theory

Based on the observed phenomena, we use the theory of transaction cost [9, 25] to explain the choice of illegal transactions methods. We first define the characteristics of illegal transactions and anonymous online market transactions. Then we analyze the transaction attributes of illegal transactions and the trends of illegal transactions.

### 6.1 Characteristics of transactions

For illegal transactions, there are three main characteristics.

**High profits** As we have known, because of the high profits of illegal transactions that vendors will still take risks under the severe attack of law enforcement agencies. Moreover, with the strengthening of law enforcement in various countries, the prices of illegal goods (such as drugs) are increasing year by year.

**High risk** As mentioned above, illegal goods such as drugs are all traded goods severely cracked down by law enforcement agencies in various countries. The conduct of transactions may be interfered and blocked by law enforcement agencies. Therefore, illegal transactions are risky.

**Ongoing demand** The most typical example here is drugs. Since drugs can be addictive to the user, the long-term needs of the user are formed, so the demand is frequent and continuous.

For anonymous online market transactions, the characteristics they have are as follows:

**Anonymity** Based on the market environment of the anonymous online market, both parties to the transaction access market through Tor network, so neither party can know the true identity of others.

**Freedom** The anonymity of the anonymous online market has brought certain difficulties to the supervision of the relevant departments. Therefore, the goods sold in such markets have a very high degree of freedom.

**Difficult to track** Anonymous online market uses cryptocurrency as transaction currency. The flow of funds in such currencies is difficult to track.

Next, we explore the impact of transaction attributes of illegal transactions on transaction cost.

### 6.2 The impact of transaction attributes of illegal transactions on transaction cost

In 1985, Willianmson [20] proposed the theoretical basic behavioral assumptions of transaction cost. Transaction cost refers to the sum of various costs such as money, time, knowledge and physical strength that users cost to complete the transaction. The transaction attributes that affect the transaction cost mainly include three dimensions [24]: transaction asset specificity, frequency of occurrence and transaction uncertainty. Below we discuss the transaction attributes of illegal transactions in three dimensions from the perspective of buyers and vendors.

**Asset specificity** Traditional entity illegal transactions is generally introduced by acquaintances, using linguistic and crypted words, or using special methods to disguise transactions as legitimate transactions, so it has a high asset specificity. With the development of Internet, illegal goods began to be sold through the network. Compared with the traditional, the specificity of illegal goods sold by Internet has been significantly reduced. For digital goods, such as cyberattack services, as Wegberg et al. studied [8, 22], that is, can be sold in the form of commodities and have lower asset specificity.

**Frequency** Drug buyers are generally addicted to it, so they have a sustained purchase of drugs, which has a large demand and a high frequency of transactions.

**Uncertainty** Uncertainty in illegal transactions comes mainly from the credit problems of both parties. Because

sellers may be fraudulent, it is often difficult for buyers to determine the seller's credit. At the same time, it is difficult for sellers to confirm whether the buyer is a true buyer instead of a law-executor, therefore it has high uncertainty.

First, we can see from the transaction attributes of illegal goods that the freedom of an anonymous market can reduce the asset specificity of illegal transactions, there is no binding relationship between the buyer and the seller. Based on the high demand and high frequency of illegal transactions, the anonymous online market transaction mode is simple, and the high degree of freedom can guarantee the frequency of transactions. In terms of uncertainty, Dream Market and other markets provide escrow mechanisms and evaluation mechanisms. Besides, account verification mechanisms and reporting mechanisms can reduce the uncertainty of transactions. At the same time, the anonymity of online networks also reduces the risk of exposure of both parties involved in the transaction. Therefore, anonymous online market transactions can reduce the transaction cost of illegal transactions.

### 6.3 Trends and choices

For the characteristics of transaction attributes of illegal transactions, transaction cost can be greatly reduced through anonymous online market transactions. At the same time, in terms of market price, we compare the (drug) data released by the relevant agencies such as the United Nations [5] with the average price of the goods classification in Dream Market. The goods price in Dream Market is roughly between retail and wholesale prices, which means that the buyer can buy goods from anonymous online market at the right price, and sellers can also get more profits by issuing multiple items and increasing market credit lines. The market uses Bitcoin for transaction, and the flow of funds is difficult to track, further reducing the exposure of both parties to the transaction. It can be seen that the anonymous online market provides a relatively reliable transaction environment for illegal goods transactions, and anonymous cybercrime will become more and more popular, which will become the focus of law enforcement agencies in the future.

## 7 Discussion

In the Section 4, we studied the types of goods in the Dream Market and found that about 90% of them were drugs and digital goods, which reflected the huge demand for the two types of goods, and also contained huge benefits. Compared with drugs that have always had a large number of user needs, the emergence of a large number of digital goods and global sales also reflect various copyright, privacy and security issues caused by the rapid development of Internet technology in recent years. On the other hand, through our research on the account verification of the market, we find that many vendors use the same nickname in multiple markets, regardless of whether these markets still exist or not. These vendors who use the same nickname display their relevant information in other markets through the account verification in the Dream Market, so that buyers in the Dream Market trust them more. Although doing so will make vendors more likely to be part of the law enforcement target, in order to gain the trust of more buyers, these vendors are willing to take the risk. This is consistent with the characteristics of the illegal transactions we mentioned in the Section 6.

Next, we will give our discussion on Dream Market in this section. First, we discuss measurement result and ethical considerations. Lastly, we assess the increasing rampant of anonymous online market crimes and the response of law enforcement agencies.

### 7.1 Measurement result and Ethical issues

The measurements we made in previous section are relying on feedback information buyers left. If a buyer in Dream Market did not leave any feedback after purchasing the product, we will get no result. Therefore, the numbers we provide in Section 5 should be considered as a lower bound.

For ethical issues, first of all, the data we collect is public. Anyone can collect the data from Dream Market by registering an account, so there is no risk of exposing the user's privacy. Second, we use a browser-based driver. The crawler's framework is equivalent to a normal user. Of course, we have designed a GAN-based CAPTCHA recognition system, which is mainly for quick login to the website and does not constitute a network attack behavior.

### 7.2 Anonymous cybercrime and law enforcement intervention

Given the special nature of the anonymous online market, more and more illicit goods vendors and buyers will choose to trade in this market. In the first section, we introduced the development of the anonymous online market, and our research shows that Dream Market even has more goods than AlphaBay and Silk Road with greater sales. This fully reflects the rapid growth of anonymous online transactions.

The network provides vendors with a broader sales space, so that their goods can be known to users around the world. For digital goods, especially commercial cyberattack services, the network platform is undoubtedly their best channel. At the same time, anonymous online market transactions have greatly reduced transaction cost, which is also a main factor for the rapid development of the anonymous online market.

In July 2017, the multinational police unit closed AlphaBay and took over Hansa during the bayonet operation, and closed Hansa a month later. According to a survey conducted in January 2018 [6], more than half believe that they are not affected by the closure of these platforms. It can be seen that the current law enforcement measures have not had a significant impact on the anonymous online market. They need to study new law enforcement strategies to combat with anonymous cybercrime.

### 7.3 About DDoS

Now, we consider the DDoS attack during the measurement period. At present, there are mainly the following views in the forum [4].

**The attack comes from other markets.** Some believe that DDoS attacks against Dream Market come from other large anonymous online market. If this is the case, it suggests that there is a phenomenon of malicious competition in the anonymous online market, which also reflects the potential huge benefits of the anonymous online market.

**The attack comes from law enforcement.** Though our research shows that the sales of Dream Market during the DDoS attack decreased significantly, we think that the law enforcement agencies do not attack an anonymous online market through DDoS attacks to undermine market transactions.

On March 27th, 2019, Dream Market posted a message on the homepage of the website saying that it will be transferred to the platform of its partner company.

## 8 Related Work

First of all, in terms of technology, the crawling techniques and classification techniques used in this paper have similarities with researches [16, 17, 19] in this field. The difference is that we are not concerned with the implementation of specific attacks, but describe the anonymous online market as accurately as possible. We used a GAN-based CAPTCHA recognition system for website login. In terms of classification, we used methods and achieved higher accuracy.

In 2012, Christin conducted a related measurement on Silk Road [10], the largest anonymous online market at that time. In 2015 [21], they evaluated and analyzed the ecosystem of anonymous networks based on previous data and later crawled. Different from them, our main concern is not the market's ecosystem and vendor diversification, but the analysis of market data, the application of transaction cost theory to prove the trend of illegal transactions in the anonymous online market.

Wegberg and Verburgh [23] studied the change in vendors in the Dream market in 2017, with particular attention to the impact of the July multinational police force "Bayonet Action" on Dream Market vendor changes. At the same time, Wegberg et al. studied the commodification of cybercrime in Dark Market [22]. They found that commodification achieved outsourcing, which lowered the barriers to entry for aspiring criminals and could drive further growth in cybercrime. Research on cybercrime mainly includes [7, 13, 14, 18], etc., mainly focusing on buyer strategy, seller behavior and forum exchanges.

## 9 Conclusion

We complete a comprehensive measurement of Dream Market, the largest and most popular anonymous online market. We have collected market data for more than four months (October 30th, 2018 - March 1st, 2019). We have analyzed the acquired items data and observed that the major goods in the market are drugs and digital goods. We compared the number of account verification by market vendors with the transaction volume and found the relationship between vendor credit and transaction volume.

We estimate sales during the measurement period, with monthly sale exceeding $14 million. Through these measurements, we use transaction cost theory to analyze the impact of anonymous online market transaction attributes with transaction cost, proved that anonymous online markets can actually reduce transaction cost, so that traditional crime patterns will gradually transfer to anonymous network.

We discuss the growing trend of anonymous cybercrime and the corresponding intervention policies of law enforcement agencies and the recent DDoS attacks by Dream Market. We believe that regardless of the originator of DDoS event who belongs to, it reflects the potential huge profit and growing trends of anonymous online markets. Advances in technology will lead to better anonymity solutions, and we will pay attention to this.

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