FROM UNKNOWN ORIGIN TO SHADY DESTINATIONS: WHERE BITCOIN IS HEADING?#

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INTRODUCTION

Money plays a vital role in human existence, business, organisation and society from an extensive eon of time. It is a universally recognised mechanism of exchange. The social and economic literature is rich in definitions, features, nature and discussion of phenomena related to money.

According to Kiyotaki and Wright (1989), the definition of money follows a long and pervasive tradition in the economic literature according to which money is usually interpreted as a physical good which exists to facilitate trade and to make barter exchange more efficient. Keynes (1936) proposed that money is used to preserve the purchase power across time, to exchange the goods.

In most of the literature, money is defined in terms of what it does rather than what it is. Money is a medium of exchange, liquidity, store of value, means of payment (Yang, 2007) and unit of account (Doepke & Schneider, 2017).

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Yang (2007) highlighted the difference between money as a medium of exchange and means of payment. The medium of exchange refers to an asset which people regularly exchange for other goods and services, whereas means of payment refers to generally accepted methods for the delivery of money. For example, coins or notes are medium of exchange but not the means of payment. Similarly, the most liquid good in any economy is money (Jevons, 1875). Keynes (1936) and Diamond and Dybvig (1983), among others, use liquidity as a synonym for money. It is the common medium through which other goods and services are exchanged (Ostroy & Starr, 1988).

The flow of the concept is as given below:

The currency refers to the money in circulation. It is the physical form of money passed from one hand (owner) to another hand (owner) without any intermediate institutions (Innes, 1914). Money is a broader concept of currency or currency includes only coin and bank notes. It is a mode of payment widely accepted in a particular geography or economic community.

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Exhibit 1: Forms of money
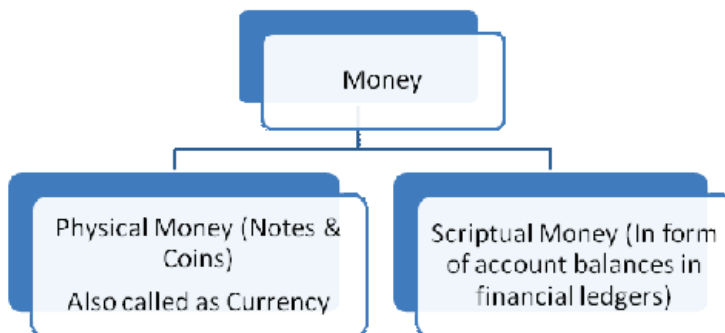
Source: Self-generated

The cryptocurrencies allow for pseudonymous peer-to-peer transactions of digital coins through decentralised payment networks . According to Financial Action Task Force (FATF), a crypto currency is 'a digital depiction of value that can be digitally traded and functions as (1) a medium of exchange; and/or (2) a unit of account; and/or (3) a store of value, but does not have legal tender status in any jurisdiction' . It includes the basic function of currency. The cryptocurrencies pretense an exceptional challenge to individual states by encroaching on a state's right to a monopoly of its own currency, yet offer a taste of a truly global free market as it only required Internet access . More than cryptocurrencies exist with market capitalisation exceeding $300 billion as on July 2018. On the other hand, the critic of cryptocurrencies argues that privacy protecting means is tremendously useful when engaged in unlawful activities .

Due to the financial crisis of 2007–2008 and the following debt crisis, centralised currency schemes came under pressure and people worldwide began to lose faith in centralised financial institutions and called for decentralisation and alternative currency schemes , and the cryptocurrency provided the answer. If a large company like Facebook does launch a currency to compete with legal currencies, it would rapidly be accepted by its members. Furthermore, the cryptocurrencies are based on blockchain technology which maintains a public ledger of all transactions which is central but distributed of all successful events in a particular chain. Each transaction has a chain of cryptographically signed digital signatures which is irreversible. Each party transmits the digital information to the next party by digitally signing a hash of the prior transaction and the public key of the subsequent owner and adding these to the end of the digital information. Any changes in the block lead to different hash, thus the changed blocks are dropped to avoid forging.

The network of bitcoin transactions between illegal users is three to four times denser than the legal user network, with users much more connected with one another through transactions . The higher density is consistent with illegal users transacting more and using bitcoin primarily as a payment system for buying/selling goods . However, despite these claims, little accurate facts exist concerning the question to what extent cryptocurrency payments originate from illicit activities.

For the purpose of this study, the reference to cryptocurrencies is stated for bitcoins as it is well-known and dominated 47.6% of market capitalisation to the entire value of cryptocurrency (Coinmarket.cap Website).

The overall research question of the study is as follows: Are cryptocurrencies with reference of bitcoin primarily used as a means of payment in criminal activities? We attempt this question by examineing the collision of sales on darknet (or dark web) market using the bitcoin as the mode of payment within the blockchain. To understand the scale of the

problem, we took the example of 'Silk Road'. As Silk Road is the first prominent example of darknet market (DNM).

The remaining portion of this study is structured as follows. The next section provides background information of cryptocurrencies and anonymous DNM. The third section presents our data set and outlines our research model. We also highlighted the limitations of secondary data and their reasons. In the last section, we present and discuss the results of our empirical study and provide direction for future research.

BACKDROP OF CRYPTOCURRENCIES AND DARKNET MECHANISM

International Monetary Fund (IMF) defines cryptocurrencies as a subset of virtual currencies which it defines as digital representations of value, issued by private developers and denominated in their own unit of account. The market for cryptocurrencies had skyrocketed in 2017, appreciating more than 1200% . Although bitcoin has no intrinsic value, no exchange value and not a legal value associated with it. At present, there are several hundreds of coins in circulation, and more continue to pop up on a regular basis. The viability of cryptocurrencies is tied to its purpose. The purpose is based on how it is classified in each country. Because bitcoin is a fully decentralised monetary system, with no central authority and regulations. Bitcoin algorithms define how currency will be created, at which pace and at what rate and make it very speculative in nature. The nature of cryptocurrencies makes them an effective alternative of cash to conduct illicit and unlawful activities . The cryptocurrencies can reduce the effectiveness of the monetary policy of central bank.

Table 1: Top Five Cryptocurrencies

Top Five Cryptocurrencies in Circulation				
S. No.	Name	Existence	Market Cap. (in Dollars)	Supply Limit
1	Bitcoin	2008	124.969.093.161	21 million
2	Ethereum	July 2015	57.462.517.858	No max. limit is fixed
3	Ripple	2012	23.790.387.789	100 billion
4	Bitcoin Cash	August 2017	17.159.025.225	21 million
5	Litecoin	October 2011	6.704.709.572	84 million
Note: All the five currencies are decentralised in nature, electronically traded, directly converted into fiat currency and pseudonymous				
Source: CoinMarket Website, 2018				

According to Houben and Snyers' report presented to the EU (2018), bitcoin can be bought with and directly converted into fiat currency on a wide array of cryptocurrency exchanges, for example, Coinbase, Kraken, Anycoin Direct and Lunco.

The 'darknet' is a network like the Internet or a combination of the websites, but that can only be accessed through particular communication protocols (encrypted network) that provide greater anonymity than the Internet (Soska & Christin, 2015). The darknet marketplaces are particularly popular for trading illegal goods and services because the identities of the buyers and the sellers are concealed. The darknet is estimated to contain approximately 30,000 domains (Lewman, 2016). The DNM use technologies such as Tor to hide the identities of its seller and customers.

In a month of January 2016 (one month alone), the total drug revenue on the darknet crypto market was estimated to be $20 million (Kruithof, Aldridge, Decary-Hetu, & Sim, 2016). Crypto-based drug market, prostitution, trading of personal information, money laundering, trading of weapons, exotic animal, identity theft and other criminal activities are serious concerns for administration around the world.

Furthermore, the risk is mitigated at various levels in this market (Soska & Cristin, 2015). First, there is no physical interaction between transacting parties; second, superior anonymity is guaranteed to compare with other options; third, escrow system helps avoid financial risk; fourth, the Coin Mixing Services such as CoinShuffle make it more attractive as it allows the effective obfuscation of transactions (Ruffing, Moreno-Sanchez, & Kate, 2014).

Evolution of Darknet Market

The term 'darknet' was first coined in 1970 to refer to networks isolated from The Advanced Research Projects Agency Network (ARPANET) which implemented TCP/IP protocol suite (Pace, 2017).

As the inter-computer interaction began to grow, 'a number of isolated, secretive networks started to appear alongside ARPANET'. These networks eventually became the medium of choice for the U.S. Naval Research Laboratory, which introduced a browser called The Onion Router (Gardella, 2006). Tor, as it is called now, 'conceals the location and IP addresses of users who download the software' (McCormick, 2013). Hyperboria is another famous browser as Tor (Hodson, 2014). The DNM is estimated to contain approximately 30,000 domains (Lewman, 2016).

DNMs are structured as e-commerce platform which facilitate the exchange of goods and money among users (buyers and vendors) and possibly generate profit through commission

fees over purchases. After a straightforward registration process (similar to any other website and where no email address is needed), which mainly involves the choice of username and password, it is possible to access the platform and start trading (Guitton, 2013). Registered users can browse the listings of goods which are sold, visit any section of the website and adjust their profile settings according to their preferences (e.g. login method and preferred currency). Moreover, searching products and filtering results are the basic standard features implemented by any platform. Multi-homing is simultaneous participation in multiple (competing) markets or platforms (Martin, 2014). This is a very common practice among darknet users which provide advantage to the seller to associate from one to up to six markets (Nurmi, Kaskela, Perala, & Oksanen, 2017).

The major concerns of the buyers are security of platform, price and quality of goods and support in case of fraud and disputes (Bergman, 2001). Vendors, instead, are likely more interested in market size and volume, competition and room for profits (Barratt, Ferris, & Winstock, 2016). Finally, both the buyers and the vendors are concerned about the risk of being exposed to law enforcement investigations.

Motivations to participation and trading in DNM are varied (Barratt & Aldridge, 2016). Typical participants are young and male (Srnicek, 2017). While many first-time users are driven by technical interest or simple curiosity. Furthermore, a large share of participants engage in regular trade, sometimes with the intention of resale (Wood, 2017).

A study conducted by CryptoMarket (2018), a leading website on cryptocurrency, mentions in their report that '97.4% of illicit activities using bitcoin originated from DNM place in year 2013–2017 and the drugs are the most popular item for purchase'.

In summary, the dark web encompasses a vast amount of information on the Internet, the majority of which is inaccessible to the average user and now the medium of choice for illegal sites ranging from drug dealing to assassination and terrorism.
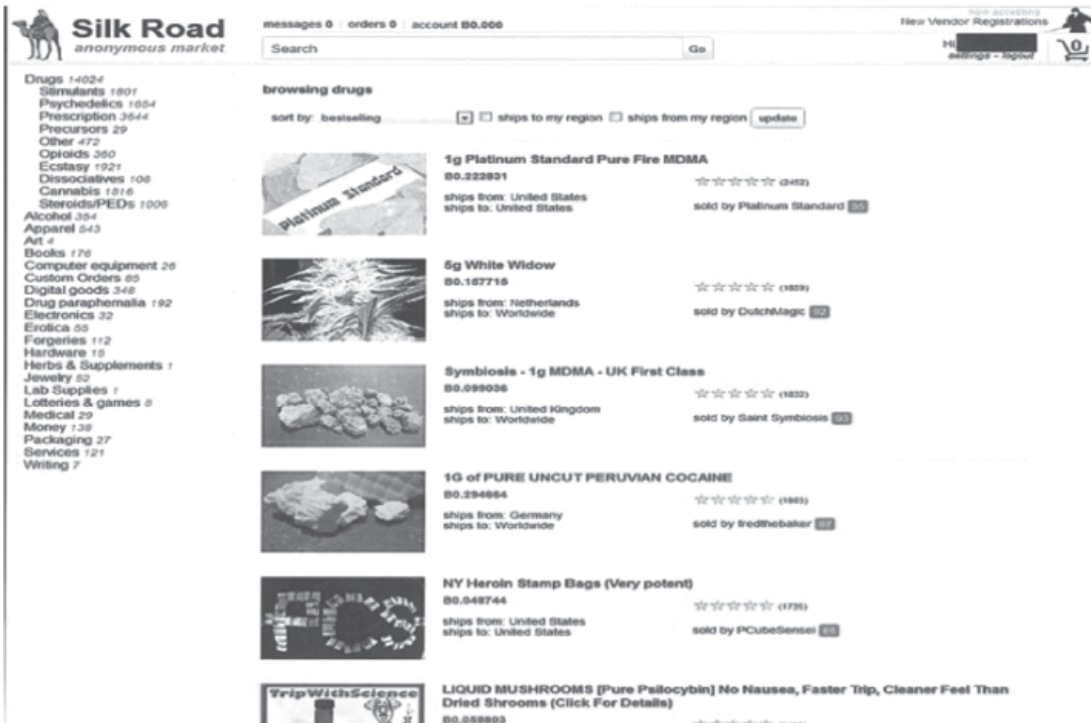
Table 2: Timeline of Darknet Market

Year	Major Events	Effect
2011	Silk Route 1.0	
Early 2013	End of Silk Route 1.0; the other major players were Ship Market, Black Market Reloaded	
End of 2013	Silk Route 2.0 started; the major players of market were Pandora, Dream Market, Tor market, Agora, Evolution, etc.	Project 'Black Flag' stole their users' bitcoin and created a panic and increased such tendency in market
November 2014	Closure of the number of darknet market; darknet market was in hidden zone	Operation Onymous by EU, made raid and shutdown various darknet websites including silk road, cloud9, hydra, etc.
March 2015	The evolution market place performed 'exit scam' stealing escrowed bitcoin worth $12 billion, half of the ecosystem listing share of the time	These exit scam happened on the name of maintenance closure before disappearing
End of 2015	Silk Road 3.0 came into existence with many more sites such as Cloud9, Tor Bazar and Alpha market; AlphaBay was recognised as the largest market	
July 2017	Market experienced largest disruption due to Operation Bayonet with multinational seizure of AlphaBay, Dream market and many more	Operation Bayonet culminated by various law enforcement agency at the same time
2018 onwards	Digital shadow reported that darknet market reportedly started shifting to direct chat options which provides more security to the transaction and the related parties	
Source: Self-generated		

We restricted our study to only Silk Route 1.0 as at that point of time Atlantas and Project BlackFlag were the major players. The reason behind considering only Silk 1.0 is that a major portion of the market was captured by only Silk Route; furthermore, Silk Road focuses on ensuring, as much as possible, anonymity of both the sellers and the buyers than any other website.

Exhibit 2: Silk Road product

Source: Silk 1.0 website, 2014

Van Hout and Bingham (2013), who conducted a case study of a Silk Road user's experience, stated that the user described 'relationships between vendors and consumers were ... based on levels of trust and professionalism' with each vendor having their own method of concealment and delivery of products that served as a demonstration of authenticity. This, along with the relative quality of the product, would be factored into a rating system that was reflected on the vendor's profile. From the consumer end, the users generally had an idea of what they were buying and what its value was (Barratt, Lenton, & Allen, 2013).

Furthermore, Silk Road is a pioneer of the consumer rating system and did hold advice on what certain drugs did and what safe practices were when handling them.

Mechanism of the Darknet

The structure of a DNM is quite similar to the structure of any other two-sided platform and enables the vendors and the buyers to trade at low transaction costs (Parker & Van Alstyne, 2013) and can be victims of different forms of deception such as non-delivery of items, product unauthentic, shill bidding and misrepresentation (Grazioli & Jarvenpaa, 2003).

Anonymousness is the basic advantage of darknet which is necessary to maintain at three stages:

a) While ordering products or service: To know the websites' option for ordering any product or service, check the hidden wikis available on Tor browser, which is similar in nature to Wikipedia which gives the detailed list of websites according to your requirement of the product. Tor's anonymisation capabilities help access and operate the hidden sites anonymously which helps in multi-homing of buyers. Further parties use public networks (WiFi) as a safeguard and use VPN sites such as Express VPN, Nord VPN and Tor Guard to remain anonymous.

b) Payment: In case of purchasing any service or item, the buyer has to pay in advance and this payment is done mainly through wallets of bitcoin or other similar cryptographic currencies. The bitcoin wallet is created with dummy names. The services of coin mixture provide additional security. To check the authentication of customers or supplier, there is a chat room service or email service available on the darknet. Thus, it becomes difficult for legal agencies to grab the parties at this stage.

c) Delivery: The product is delivered either online through mail or through courier. This is the difficult aspect for a DNM to maintain in case of physical delivery. There is very less research on the delivery system of physical products sold on the dark net market. It is necessary to understand how sellers on the DNM provide delivery at the customer's doorstep, and at this stage there are chances to be grabbed by the authorities.

There are platform-independent sellers who are active on the DNM who are able to continue sales despite shutdowns (Thijmen, 2018). The platform generates revenues through a commission on transactions and an entrance fee for sellers.

Darknet Market Characteristics

We provide an overview of the types of goods and services being sold in the darknet. There are approximately 220 distinct categories, ranging from digital goods to various kinds of narcotics, pornography or prescription medicine.

Table 3: Top 10 Items Sold in Silk Route

Category	Item	Percentage
Weeds	3338	13
Drugs	2194	9.3
Prescription	1784	7.3
Benzos	1193	4.9
Books	955	3.9
Cannabis	877	3.6
Hash	820	3.4
Cocaine	473	2.6
Blotter (LSD)	440	1.9
Money	405	1.8
Adapted from: Nicolas Christan (2013)		

We assume that the items sold on the DNMs affect the number of total transactions within the bitcoin blockchain. The rational choice theory posits that 'agents act in their perceived best interest' (Blume & Easley, 2008) using a mental cost and benefit calculation prior to decision-making (Browning, Halcli, & Webster, 1999). The emergence of the pseudonymous payment system and cryptocurrency bitcoin solves the issue in operating a DNM that protects the true identity of its users (Christin, 2013): a means of payment which cannot be used by law enforcement agencies to easily trace individuals (Soska & Christin, 2015).

Exhibit 3: AlphaBay market
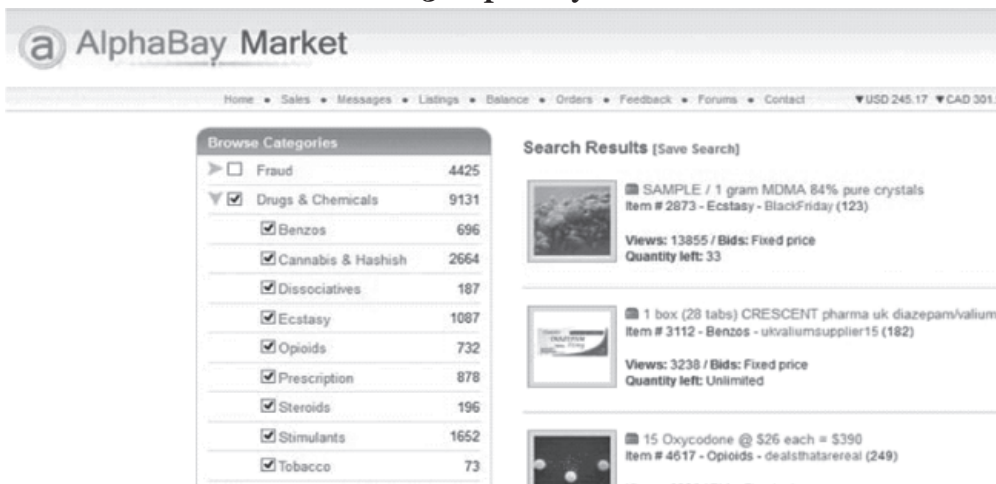
Source: TOR network

Based on the theorem of rational choice theory and nature of the items sold on the DNM, we argue that criminals prefer less identifiable ways to buy illegal items to protect their identity. This is beneficial for both the parties in comparison to conventional means of conducting illegal business.

Janetos and Tilly (2017) in their study found the following three stylised facts: '(i) there is a positive relationship between the price and rating of the seller, (ii) sellers with more reviews charge higher prices regardless of ratings, (iii) low-rated sellers are more likely to exit the market and make fewer sales'.

Furthermore, multi-homing, seller reputation and loyalty are an important aspect of the DNM to be discussed in further research.

DATA SET

We required two sets of data for our study: (a) total value of bitcoin used in Silk Route 1.0, from 2011 to 2014, and (b) the daily number of bitcoin traded and its price.

We primarily focus data collection on 'item pages', that is, pages describing the goods being sold on Silk Road. There are approximately 220 distinct categories, ranging from digital goods to various kinds of narcotics or prescription medicine.

We only consider the data which were presented during the trial of the Silk Road founder (evidence GX940) of USENIX Security Symposium. We directly take these data as there is least chance of misrepresentation in this. We did not consider the data of Atlantis, which was negligible at that time. The second set of data is taken from *data.bitcoinity.org*. This website has data of the number of bitcoin traded on major bitcoin platforms. This is the common source of data for many other research papers.

The major challenge in data collection is to get the price of bitcoin which is slightly varied at different platforms such as Coin base, Bit, BitFinex and Bit/X. They all provide different prices and many of the platforms are introduced at later stage.

RESULTS AND CONCLUSION

As per our data, the total revenue of Silk Road 1.0 was $214,000,000. These data were extracted by U.S. Government and presented during the hearing of Silk Road 1.0 case. The data were extracted solely from bitcoin transaction logs. During the period of operation of Silk Road 1.0, we analysed the total transaction values of bitcoin through various bitcoin

exchanges. From our estimation, it was around $3,147,726,191. Hence, it is fair to say that out of total bitcoin transactions, 5.81% of transactions were solely for the purpose of purchasing goods/services from the darknet.

Here, an additional thing which needs to be considered is the coin mixture services. Almost all the transactions, which ended up in the dark web, are routed through the coin mixture services. Now, the above value of $3,147,726,191 does include transactions such as mixing up the coins and transferring the same would also be considered as transaction. However, the ultimate purpose of most of these kinds of transactions would be purchase of illicit item or service from the darknet, and hence from our point of view these kinds of transactions should also be considered as the darknet transactions. As it is not possible to calculate such transactions and it is not fair to say that all transactions routed through coin mixture services end up in the dark web, we estimated those values by backward integration. About 5.81% of transactions are those which are ended up on the darknet websites. Now, even if such transactions are routed through at least one cycle of coin mixing cycle, there was at least one transaction prior to each transaction, which ended up in the darknet. However, the uncertainty of the figures and the unavailability of the data made it impossible to find the exact figure, and hence, we have taken conservative approach of 5.81%.

It is evident from the data that each and every website on the darknet is accepting bitcoin as its prime currency. Over and above bitcoin, there are other currencies which are mostly based on the blockchain concept. Out of a sample size of 46 websites considered in the study, 5 websites did not mention their method of payment, 1 website provided service free of cost and only 12 websites were expecting currencies apart from bitcoin. Although it is worth mentioning here that even in these 12 websites bitcoin is also available as an option of payment. It is fair to say that out of all websites which have mentioned their payment method, 71% of the websites were exclusively operating only through bitcoin.

Hence, it can be very well said that every transaction done through bitcoin does not end up in the dark web; however, around 75% of transactions, which end up in the dark web, are routed through bitcoin. This creates a question mark on the usage of bitcoin and the basic motive to create a parallel currency which solves the problem of cash management which remains the same. The cryptocurrency does not solve the issue of legal tender; rather, it creates a new issue, that is, criminal usage of cryptocurrencies and its heading towards the new low.

LIMITATIONS

Our study is confronted with several limitations. First, our study focuses on bitcoin as a proxy for the cryptocurrencies. However, there are more than 2000+ cryptocurrencies currently traded in the darknet.

Second, we draw on data of 46 DNMs as a proxy for organised crime that is associated with cryptocurrency usage. It is possible that our analysis did not capture all the relevant criminal usage of the cryptocurrencies.

The third major issue is related to the daily price of the bitcoin. The daily number of bitcoin traded is the multiplied price on that particular date. As there are multiple trading platforms available, there is marginal change in the price of bitcoin at every trading platform. This creates the problem of taking weighted average price for calculation. Hence, we took simple average.

Fourth, the websites which are operating in the darknet are illegal, and hence due to various reasons such as government raids or exit scam, these websites close down on frequent basis and again open themselves with some other name.

Fifth, we are not much clear about the delivery system of the DNM and are not able to find the literature on this aspect of DNM to the best of our knowledge.

FUTURE SCOPE

From a technical standpoint, this work is closely related to rapidly growing literature on measuring the relationship of the cryptocurrencies in cybercrime. The main difference between this work and the related cybercrime literature is the object of the measurements.

Instead of trying to characterise a security attack or the behaviour of an attacker or the part of the system by opening an account on the darknet and conducting a transaction, we simply took the secondary data from the evidence presented by the American Government and bitcoin daily transaction log. This research is based on the past data. Our study has a link with McCoy, Bauer, Grunwald, Kohno, and Sicker (2008), which provided a characterisation of traffic using the Tor network by monitoring a Tor exit node. Different from this research, we do not actually monitor the Tor traffic and instead analyze the data posted to an online marketplace and Silk Road.

Thus, pseudonymous cryptocurrencies such as bitcoin are oftentimes associated with illicit activities such as drug trafficking, arms trade, pornography and other illegal activities. Future work in this area could investigate whether and how the value of goods and services sold on DNMs are associated with the total value of cryptocurrency transactions in the underlying blockchain.

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