

**Actors and Purchases on the Cryptomarket  
Ecosystem: Administrators, Vendors, and Products**

by  
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## **Abstract**

Cryptomarkets are marketplaces on the dark web that facilitate the sale of, mostly illicit, goods and services between vendors and buyers. There were few to no studies that examine the cryptomarket ecosystem using data from multiple cryptomarkets collected at one point in time. This study strives to fill that gap by using eight large and notable cryptomarkets collected from June 2021 to January 2022 to understand the cryptomarket ecosystem, the products available, and identify factors that encourage or discourage actors from engaging in business on cryptomarkets. Eight cryptomarkets and 3,825 unique vendors had an estimated income of \$378.5 million annually.

Administrators of the largest cryptomarket, White House Market, made \$11.3 million annually, showing there is financial incentive to open cryptomarkets. Drug vendors can choose the risk they take based on their experience, their amount of business, if they are a generalist, and the price and quantity of the drug package.

**Keywords:** cryptomarkets; administrators; vendors; drugs

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## List of Acronyms

CAPTCHA	Completely Automated Public Turing test to tell Computers and Humans Apart
Dark0de	Dark0de Reborn
DDoS	Distributed Denial of Service attack
ICCRC	International CyberCrime Research Centre
IP	Internet Protocol
TDC	A web crawler created by the International CyberCrime Research Centre at Simon Fraser University to access the dark web and collect data.
Tor	The Onion Router
URL	Uniform Resource Locator
WHM	White House Market

# Chapter 1. Introduction

Cryptomarkets are marketplaces on the dark web that gather multiple buyers and vendors for the trade of, often illicit, goods and services (Christin, 2012; Martin, 2014; Bradley, 2019; Barratt, 2012). These anonymous markets can provide individuals with a less monitored, alternative route to access products outside of more traditional in-person methods of trade. There have been many cryptomarkets that have appeared and disappeared over time (Branwen et al., 2015; Dark Web Link, 2021; Dark.link, 2022). Silk Road was a large cryptomarket that first appeared in 2011 and was the largest cryptomarket of its time (Christin, 2012). Since Silk Road, the cryptomarkets that appeared after it had grown in the number of cryptomarkets available, amount of profit gained, and sophistication of security measures used (Aldridge & Décary-Hétu, 2014; Zhou, Zhuge, Fan, Du & Lu, 2020; Lane et al., 2018). Cryptomarkets are an emerging field of cybercrime that has been rapidly growing since 2011 (Martin, 2014), and is likely to continue growing and evolving. As such, cryptomarkets could become a larger crime vector that facilitates greater amounts of criminal activity across the cryptomarket ecosystem. Many studies have examined a single cryptomarket in-depth or have examined multiple cryptomarkets from different time periods (Aldridge & Décary-Hétu, 2014, 2016; Barratt, 2012; Bradley, 2019; Christin, 2012; Aldridge & Askew, 2016; Broseus et al., 2017b).

This study intends to examine the cryptomarket ecosystem as close to one time as possible to allow for a better understanding of the cryptomarket ecosystem. It would allow for a more accurate estimation of the number of transactions and types of items that are being facilitated by cryptomarkets, the effects of cryptomarkets on each other, and the vendors available across cryptomarkets. Individual cryptomarkets may have specific rules that affect the products and services allowed on the market. By analysing the data from all cryptomarkets involving the sale of products, it is possible to gain a holistic image of the trends and patterns of products, vendors, and cryptomarket administrators. Gathering data from multiple cryptomarkets would allow the study to identify the number of unique vendors by usernames across cryptomarkets and vendor migration trends after a cryptomarket shuts down. Data was collected from multiple cryptomarkets consecutively from June 2021 to January 2022. Similar information was

extracted from all cryptomarkets, when the information is available, in an attempt to make the analyses uniform across all cryptomarkets.

The actors on cryptomarkets such as administrators and drug vendors consider their choices and decide to conduct their business on cryptomarkets. Rational choice theory argues that offenders will make choices that benefit themselves if they see an opportunity and are willing to take it to obtain their goal (Clarke & Cornish, 1985). This study will examine the financial benefits that cryptomarket administrators and vendors gain by conducting business on cryptomarkets. There has been no lack of accessible vendors looking to profit on cryptomarkets despite disruptions and shutdowns. The movement of vendors between cryptomarkets will be examined to determine if the same set of vendors move between cryptomarkets to continue business or if newer vendors often replace previous vendors.

Drug products were often the largest category of product available on cryptomarkets (Barratt, 2012; Christin, 2012; Baravalle, Sanchez Lopez, & Lee, 2016; Broseus et al., 2017b) and drug products have a physical location, requiring shipping. Drug products and vendors will be examined in greater depth to identify factors that affected the availability of the option to ship drugs internationally. Drug vendors are likely to be influenced by certain characteristics when they decide where they are willing to ship products to, such as their experience in shipping drugs, how many more drug products they can sell, and the perceived risk. Vendors who sell high-risk goods, fentanyl or firearms, will be examined to determine if they have unique characteristics compared to the average vendor. Other characteristics that may affect the ability of a drug vendor to ship products worldwide include the product's price, quantity, and dosage. These characteristics could affect the vendor's perceived and actual risk of shipping products internationally. Following this, it will be determined if cryptomarkets are primarily used to sell bulk amounts of a product for the purpose of resale.

The following research questions (RQ) will help identify what factors influence the cryptomarket administrator and vendor's decision to use cryptomarkets when conducting business, using data from multiple cryptomarkets at one point in time. This allows for a wider range of analysis and the ability to examine cryptomarkets, vendors and products holistically.

RQ1: Cryptomarket administrators make a sufficiently large profit which may encourage them to continue to operate cryptomarkets and facilitate the trade of illicit goods and services.

RQ2: The group of vendors remain static as the same set of vendors move between different cryptomarkets to sell products and services.

RQ3: There are characteristics that will influence a drug vendor's ability to ship drug products internationally, such as more experience on cryptomarkets (RQ 3A), a greater number of drug products they sold (RQ 3B), a greater variety in the types of products they can sell (RQ 3C), and the number of cryptomarkets they were found on (RQ 3D).

RQ4: Drug packages have characteristics that will affect if vendors decide to ship packages internationally, such as the price (RQ 4A) and quantity of a product (RQ 4B).

RQ5: The majority of the drug transactions are for personal use rather than wholesale.

Other studies have examined similar topics and can be used to provide a comparison for both how much cryptomarkets may have changed over time and how features and products may differ between cryptomarkets (Aldridge & Décary-Héту, 2014, 2016; Barratt, 2012; Bradley, 2019; Christin, 2012; Aldridge & Askew; 2016; Broseus et al., 2017b). No studies were found that examined the drug and firearms cryptomarket ecosystem using multiple cryptomarkets at one point in time. Exploring the overall cryptomarket ecosystem allows this study to gain more information about the overall functioning of cryptomarkets, administrators, vendors, and buyers across multiple large cryptomarkets and firearm cryptomarkets.

## Chapter 2. Literature Review

Since 2011, when the first cryptomarket was created, it has become easier to avoid face-to-face meetings with a dealer to buy a variety of illicit products and services. These anonymous online markets are called cryptomarkets, they use cryptocurrency and other anonymising software to protect their users (Martin, 2014). The web is split into three parts (Unterfingher, 2019); 1) The surface web, which contains roughly 4% of all content on the web with indexed results that appear on search engines such as Google or Bing. 2) The deep web, the largest section of the web, is unindexed and requires a password or other credentials to access, such as medical records. 3) The dark web, also unindexed, can be accessed using onion type links and is hidden through encryption and software. The majority of cryptomarkets are only accessible by The Onion Router (Tor) (Unterfingher, 2019), a browser that will encrypt a user's data and send it through a relay network (Nastula, 2018). Tor offers anonymity to the user and obscures their Internet Protocol (IP) address by sending it through the Tor relay network (Nastula, 2018), providing the user with some protection when browsing the dark web (Aldridge & Décary-Héту, 2014; Lane et al., 2018). For anyone tracking the individual's IP address, it would appear as if they were at the last relay node in the network rather than where they are located. Occasionally, the invisible internet project can be used to access the dark web and some cryptomarkets (I2P, 2019).

There is no inherent trust on the dark web between those selling products (vendors) and those interested in purchasing products (buyers). Without trust, it is difficult to buy or sell illicit products between anonymous parties that can easily create a new identity. Vendors and buyers may worry about being scammed and having no way to reduce the potential risk of financial loss. Both parties were involved in the trade of illicit goods, therefore, they are less likely to contact law enforcement than those trading licit goods and know who the other party is. Cryptomarket administrators run a business by being trustworthy enough that anonymous parties are willing to trade with each other by providing security and safety features. The purpose of a cryptomarket is not to personally sell products, but to connect vendors and buyers for the sale of goods and services (Bradley, 2019; Barratt, 2012; Christin, 2012; Martin, 2014). In exchange for facilitating trades and offering a platform with safety features to trade on, cryptomarkets will take a percentage of each transaction (Christin, 2012; Martin, 2014). The

cryptomarket administrators, vendors, and buyers appear to be rational actors who have deemed the potential benefit of trading on cryptomarkets to be worth the risk.

Cryptomarkets use a safety feature called escrow to prevent scams between buyers and vendors, where the cryptomarket has control of the money until the deal is finalized. Buyers will pay for a product and send the money to escrow where the money is held until the product is delivered or the timer runs out and the deal is automatically finalized. Once the product is delivered, the buyer is expected to finalize the deal and release the money to the vendor. If the buyer is unsatisfied or the vendor did not send the product, the buyer can reset the timer on escrow to gain more time or start a dispute with the vendor to obtain a refund. The cryptomarket will facilitate the dispute and determine if the money should be released to the vendor or refunded to the buyer. With the cryptomarket facilitating and ensuring fair deals, the need for trust between the vendor and buyer is diminished. So long as the buyers and vendors trust the cryptomarket, they can continue to trade with anonymous parties in exchange for a small fee. Some cryptomarkets will break this trust by exit scamming. They shut down the cryptomarket and take any remaining funds in escrow when they leave, robbing the buyers and vendors.

Not all cryptomarkets exit scam, some cryptomarkets are seized by law enforcement. Others will shut down voluntarily by announcing that they are closing operations and give buyers and vendors some time to withdraw their funds before shutting down. Some cryptomarket administrators might be fearful of law enforcement intervention because their cryptomarket is a larger market or trades in high-risk items, therefore, they are more likely to be targeted. There is a limit to the amount of security the market can enforce while still efficiently facilitating trade (Morselli, Giguère & Petit, 2007), forcing the market to take on risk. By voluntarily shutting down, administrators may believe they can greatly reduce the risk of being caught. If the cryptomarket has faced significant struggles, such as distributed denial-of-service (DDoS) attacks, administrators may decide that it is not worth the effort to keep the market active and decide to shut down. Many cryptomarkets are short lived, yet some are able to develop into larger and older cryptomarkets which facilitate hundreds of millions of dollars worth of drug trades (Aldridge & Décary-Hétu, 2014; Zhou, Zhuge, Fan, Du & Lu, 2020).

## 2.1. Cryptomarket Lifecycle

New cryptomarkets appear and shut down regularly, without greatly affecting the number of vendors and buyers on the cryptomarket ecosystem (Bradley, 2019). When large cryptomarkets shut down, the vendors and buyers will migrate to different cryptomarkets. There is an opportunity for other cryptomarkets to claim the title of the largest market and this gives newly created cryptomarkets an opportunity to rapidly grow when vendors research which cryptomarket they should sell on next (Hout & Bingham, 2014). The majority of cryptomarkets last a few months to a couple of years before they exit scam, shut down, or are seized by law enforcement (Branwen, 2018), and are rapidly replaced by new cryptomarkets. Between 2011-2015, there were at least 91 cryptomarkets that appeared and shut down, nearly none of them existed for three years or more (Branwen et al., 2015). There are a few exceptions to the trend of short lived cryptomarkets, such as Dream market. It appeared in November 2013 and appears to have voluntarily announced their shutdown in April 2019 (Madore, 2019). There have been at least 171 cryptomarkets that appeared between 2011 to 2022 (Branwen et al., 2015; Dark Web Link, 2021; Dark.link, 2022).

With new cryptomarkets willing and able to take in buyers and vendors from defunct cryptomarkets, the cryptomarket ecosystem has shown itself to be highly resilient to disruptions (Bradley, 2019; Buskirk et al., 2016; Décary-Héту & Giommoni, 2016). The ecosystem regularly recovers from law enforcement intervention and exit scams, all while increasing in capacity. Individual vendors tend to be resilient to the financial losses that occur when a cryptomarket shuts down (Bradley, 2019), such as losing the money remaining in escrow or the market wallet. If only funds are lost, then it is less harmful to a vendor's operations than if their reputation or client base are lost or inaccessible (Bradley, 2019).

The amount of revenue a larger cryptomarket generates is increasing. There were a few methods of estimating the size of illicit markets; supply or demand side estimations (Kilmer et al., 2011). Under the demand side estimate, there are two potential estimates (Kilmer et al., 2011); 1) the consumption-based estimate which uses the number of users and frequency of use, 2) the expenditure-based estimate which considers the number of users and the amount of money spent on drugs. Identifying the number of users on the cryptomarket who purchase these products can be difficult,

however, there are visible sales which often contain the price. An estimate based on the annual amount spent on drugs will be used in this study, which is in line with other studies (Aldridge & Décary-Hétu, 2014; Zhou et al., 2020; Monk & Frank, 2019).

To show the growth of cryptomarkets, this study used Monk and Frank's (2019) method to compare the Silk Road to Dream market, both were the largest cryptomarkets of their time. Silk Road's drug sales were estimated to be \$89.7 million USD annually (Aldridge & Décary-Hétu, 2014). It was calculated by the number of monthly reviews multiplied by its listing price. Dream market had made an estimated \$168-200 million USD annually (Zhou et al., 2020). The amount of money flowing through the largest cryptomarkets between 2013 to 2018 nearly doubled.

## **2.2. Products**

Cryptomarkets often allow a large range of products to be sold on their site. Commonly sold items include drugs, forged items, credit card and bank information, tutorials on various subjects, and databases from hacked sites. Yet, there is often a limit to what cryptomarkets will allow. The majority of cryptomarkets will ban certain products to reduce the risk that law enforcement will target their markets, such as child exploitation material, assassination services, weapons, and fentanyl (Bradley, 2019; Lane et al., 2018; Morselli, Giguère & Petit, 2007). Cryptomarkets may have decided that it is also unethical for some products, such as child exploitation material, to be sold on their platforms. Other cryptomarkets may have grown too large to effectively and efficiently find and ban all the products they had forbidden from the market.

Drug products are the most common listings available on cryptomarkets. It is estimated that between 63-80% of listings are drugs or drug related products (Barratt, 2012; Christin, 2012; Baravalle, Sanchez Lopez, & Lee, 2016; Broseus et al., 2017b). Vendors must package the product, then deliver the package using a postal service. In an attempt to reduce the odds of the package being caught, vendors use stealth methods when shipping the product. For example, vendors will use mylar bags, vacuum seals, and printed shipping labels during packaging to prevent the package from being flagged and to allow buyers peace of mind. Vendors will also rotate which mailboxes they use when they drop off packages to try and hide their location (Aldridge & Askew, 2016; Smith & Frank, 2020).

Digital products were the second most common category of product, increasing in popularity over time from 1.1% of all listings on Silk Road in 2011 and 2012 (Christin, 2012) to 40% on Dream market in 2018 and 2019 (Zhou et al., 2020). This would include anything in a form that can be transferred over the internet. Often, information on credit cards, usernames, passwords, and other personal information was available. Recently, with the rise of 3D printing, there had been blueprints for 3D printed firearms for sale. Physical weapons were also sold on cryptomarkets, with significantly fewer listings. Rhumobarbe et al. (2018) found 386 listings for weapons, with 25.4% of those listings as firearms. Paoli et al. (2017) found 811 weapons listings on 12 cryptomarkets, 42% of the weapons were firearms. Similar to the delivery of drug products, weapons rely on the postal service to be delivered. Firearms and weapons are often made of metal and are larger than drugs, making them easier to find despite the vendor's best attempts at stealth. Weapons are considered to carry a much higher risk than drugs when they move through the postal system (Paoli et al., 2017).

Some products will not be purchased while others will be purchased many times over. Reviews for each product will be used to estimate the number of sales. Reviews can be found across nearly every cryptomarket and are the most uniform method to accurately gauge the number of sales a product has. Other studies use reviews (Aldridge & Décary-Héту, 2014; Zhou et al., 2020), allowing it to be a decently uniform metric to examine the growth of cryptomarkets over time.

### **2.2.1. Drug Products**

As the most found product, there is a great variety of drug products for sale. The drug categories are generally comparable across cryptomarkets with the most common ones being benzos, stimulants, dissociatives and psychedelics. The specifics within the drug section will greatly differ between and even within markets (Hout & Hearne, 2017). There can be many novel substances that are not easily classified within existing categories. Some novel substances include synthetic opioids or fentanyl analogs (Lamy et al., 2020). Despite the ban on the sale of fentanyl in certain markets, some listings still offer fentanyl on the same markets (Lamy et al., 2020). Lamy et al. (2020) found that the average price per gram of non-pharmaceutical fentanyl was \$1,898 for listings under 5 grams and \$177 for wholesale listings with 5 grams or more. This shows a significant discount for wholesale listings, potentially encouraging buyers to buy more fentanyl.

Fentanyl and opioid products could be of particular interest because of the increased chance of overdosing. Canada, for example, had a significant increase in the number of opioid overdose deaths from 2019 to 2020 (United Nations Office on Drugs and Crime, 2021a).

There are different definitions of wholesale drug products. Lamy et al. (2020) defined wholesale of fentanyl products as 5 grams or more to acknowledge the potency of synthetic opioids. That definition is specific to opioids and would not apply well to other substances such as cannabis. Aldridge and Décary-Hétu (2016) set a conservative estimate of \$1,000 USD because they expected that the majority of products costing over \$1,000 USD would be for resale or social use rather than personal use. Converting it to CAD, any listing over \$1,271 CAD will be classified as wholesale. This threshold will be examined using the data and it will be determined if the threshold is still reasonable for use. Certain drug packages may face greater risk than other packages. Some examples include: 1) If the package is shipped internationally or to countries that have a greater likelihood of seizing the products (Smith & Frank, 2020). 2) The quantity shipped, larger shipments may have a greater chance of being caught (Décary-Hétu et al., 2016). 3) The price of a product can be a direct indicator of the risk the vendor takes on. The price of the product is what the vendor may lose if the package is seized by law enforcement. While a greater price itself may not necessarily increase the chance a package is seized, it can be a greater risk for the vendor (Reuter & Kleiman, 1986).

One of the largest costs of drug dealing is the compensation for physical risk, which can cost 33% of the total revenue (Caulkins & Reuter, 1998). This risk is nearly non-existent in cryptomarkets, thus, the prices for drugs on online markets may be significantly lower due to the removal of the risk of physical violence. Examining the characteristics that may influence if a vendor is willing to ship products internationally could assist in identifying the potential risks the vendor is willing to take and the packages which may be more likely to be shipped internationally.

### **2.3. Vendors**

Vendors are an essential party in cryptomarkets, providing the products for buyers to purchase. They research the cryptomarkets they consider conducting business on and will spend weeks interacting with other members to determine if joining that

cryptomarket would be profitable (Hout & Bingham, 2014). Once they have determined which cryptomarket they would like to sell on, they create an account and pay the vendor bond, if there is one. The vendor bond is a fee that vendors pay to the cryptomarket when they first become vendors to discourage vendors from exit scamming right away. The bond often ranges between \$50-\$1,000 (Dark Web Link, 2022). If vendors cannot scam back the price of the vendor bond, they would lose more money from scamming than they would gain. This discourages scamming and incentivizes vendors to continue using the cryptomarket because they had already paid a fee. Some cryptomarkets will allow trustworthy vendors who have a good reputation and are well known on other cryptomarkets to join their cryptomarket without paying the vendor bond. This allows cryptomarkets to grow and encourage buyers to join the cryptomarket because of the large number of options and trustworthy vendors available on that market.

Cryptomarket vendors and surface web online sellers in a competitive online market face similar challenges to attract buyers (Xu et al., 2017). Surface web buyers, when buying high-risk or hedonic products, consider custom web design, purchase security, fast shipping, customer support and refund opportunities important (Xu et al., 2017). As a consequence, the vendors will focus on providing those. Many products available on cryptomarkets would be considered high-risk and hedonic products, like drug products. Cryptomarket vendors do not choose the web design and the purchase security is already built into their transactions, however, vendors can provide refund options, customer support, quick response times, a delivery timeline, and offer faster shipping in exchange for a larger price. As these vendors make conscious decisions to appeal to the buyer population, they become more attractive than those who make no efforts to satisfy buyers. Buyers purchased 60% of products in one product category, such as drugs, from their preferred vendor (Décary-Hétu & Quessy-Dore, 2017).

Once the buyer has a positive experience after purchasing from the vendor, the buyer may trust and prefer to purchase products from the same vendor when possible. If the vendor sells a large variety of products, the buyer may use them for all their needs as one-stop shop. Décary-Hétu and Quessy-Dore (2017) found that this was not the case, likely because specialists are able to obtain a higher quality product and ship the product with greater ease, offering greater value per dollar. Buyers can be loyal while purchasing products from multiple vendors (Décary-Hétu & Quessy-Dore, 2017). They purchase from their first choice of vendor when the vendor is available and reasonable,

then switch to other choices when their first choice is inaccessible (Décary-Hétu & Quessy-Dore, 2017) or the price becomes unreasonable for the value. With the competition clearly visible to buyers, vendors are not able to sell significantly above market price while expecting to retain their buyers. On the other hand, if a trustworthy vendor was consistently available and sold their products around the market price, they may retain a greater number of loyal buyers.

The economical calculation for profit is not the only consideration that vendors have, vendors also appreciate the safety and security that avoiding face-to-face meetings offer them (Martin et al., 2020). By avoiding any physical meetings, vendors become more difficult to find because buyers do not know who the vendor is. This greatly migrates the risk that vendors will be caught because of a buyer telling law enforcement who sold the illicit products (Martin et al., 2020; Barratt et al., 2016). Drug deals on cryptomarkets were perceived to be safer, more stable, and courteous than offline dealing by vendors (Martin et al., 2020).

Several vendors also report feeling a thrill, having more control over their work, and long-term enjoyment in their work (Martin et al., 2020). Vendors are able to decide their own hours, how much to expand their business if there is demand, and how much risk they are willing to take on. Being a drug vendor on a cryptomarket appeals to the values of safety, control, profit, and professionalism (Martin et al., 2020). Some drug vendors would not have otherwise engaged in the trade of illicit goods and services if not for cryptomarkets (Martin et al., 2020). Cryptomarket vendors have the opportunity to hone their skills and knowledge in selling products and engaging with buyers. They may lose the vendor fee if they believe their reputation is too negative or unsalvageable and need a new vendor identity, however, there is little risk of a physical confrontation. Vendors are able to learn and become more professional, gaining pride and skill in their work, which can increase the likelihood that they continue selling illicit goods and services (Clarke & Cornish, 1985). When a cryptomarket shuts down, those with a greater reputation and ability to satisfy the buyer's expectations are more likely to continue to sell products (Bradley, 2019). The vendor may lose money on the uncompleted transactions on cryptomarkets when they shut down, however, vendors are aware of the potential for financial loss (Martin et al., 2020).

In addition to vendors' worries that the cryptomarket they conduct business on may disappear, vendors may worry about buyers. Buyers may attempt to scam vendors by arguing their product was not delivered and leaving negative reviews to lower the vendor's reputation. A poor reputation can make the vendor seem unattractive to buyers and hinder their business. Large numbers of their packages being seized are likely to negatively impact their reputation as well. Package seizures are a risk to both online and offline dealing and it is unknown if packages are more often seized from online deals or offline (Décary-Hétu et al., 2016). Uncertainty is also considered a cost (Reuter, 1985). If a product is seized, law enforcement may attempt to track the vendor's location. Every seized package may increase the chances that the vendor is caught. Overall, cryptomarket vendors are willing to tolerate a financial loss, considering it as the "cost of doing business", in exchange for greater physical safety and security (Martin et al., 2020; Barratt et al., 2016).

There is less known about buyers on cryptomarkets because there is no need for buyers to advertise themselves on cryptomarkets or make themselves easily accessible. Vendors aim to be known in a positive light and are visible on cryptomarkets to post listings and advertise their products to gain more buyers. Vendors may be able to see the buyer's profile page if the buyer initiates contact so the vendor can decide if they are willing to sell to the buyer. Without the initial contact, it can be difficult for any user to find buyers. Buyers do not post listings and the reviews will often anonymize the buyer to some degree. For example, some markets anonymise their buyers' reviews by replacing their name with six asterisks while others show the first and last letter of the buyer's name and replace the rest with asterisks. It is difficult to find information on cryptomarket buyers while having a high degree of certainty that the buyer is the same. Vendors and product reviews were the focus of this study.

With the abundant opportunities for skilled individuals to open cryptomarkets or for vendors to sell illicit goods on cryptomarkets, there will likely be an increase in crime corresponding to the available opportunities (Clarke & Cornish, 1985). The products, vendors and administrators of the cryptomarket ecosystem will be examined to identify the profits individuals can make when conducting business on cryptomarkets. Certain characteristics of vendors and drug products may encourage or discourage international shipments because of the risk and potential profit associated with international delivery.

## **Chapter 3. Methods for Quantitative Cryptomarket Crawl**

To gain a holistic picture of the cryptomarket ecosystem, data collection first had to identify the large and notable cryptomarkets. Notable cryptomarkets were cryptomarkets that sold higher-risk items, such as firearms or fentanyl, while large cryptomarkets were the cryptomarkets with the greatest number of listings available.

### **3.1. Cryptomarket List**

To determine which cryptomarkets should be crawled, a list of cryptomarkets was created. All cryptomarkets were collected in January or February 2021 from dark web forums, a cryptomarket spreadsheet from law enforcement, and dark web sites that listed cryptomarkets. The majority of cryptomarkets required the user have an account before allowing them to access the cryptomarket. Accounts were created on all cryptomarkets to identify and estimate the size of the cryptomarket. The cryptomarkets would be examined to determine if they sold firearms or were large cryptomarkets that could further our understanding of the cryptomarket ecosystem. All cryptomarkets were examined at least twice, once in January or February for the initial estimate and once in March for any major changes. If any cryptomarkets were not active in January due to DDoS attacks, they were reviewed in March 2021 and September 2021 to determine if the market held sufficiently notable information to justify the time cost of crawling the market. If a cryptomarket sold firearms or fentanyl, was one of the largest markets, or rapidly grew into a large market, there would be an attempt to collect data from the cryptomarket. The final number of products in March 2021 was the number used to determine which cryptomarkets were the largest markets. If a cryptomarket was inaccessible in March, it was re-examined in September to determine if it may be an important cryptomarket in the cryptomarket ecosystem.

Table 3.1 lists the 32 cryptomarkets that were identified. Only English speaking cryptomarkets were collected because of the language barrier hindering our understanding of non-English speaking cryptomarkets. If the onion site was not found, the cryptomarket was considered inaccessible and had either been previously shut down, or the domain was missing. The four largest cryptomarkets that were available

and accessible in March 2021 were collected; White House Market (WHM), Dark0de Reborn (Dark0de), World market and Versus.

**Table 3.1 Potential Cryptomarket Data Collection List**

<b>Cryptomarket</b>	<b>Number of Products (March)</b>	<b>Drugs Available?</b>	<b>Firearms Available?</b>	<b>Additional Comments or Number of Products in September</b>	<b>Collected?</b>
White House Market	44,163	Yes	No	Largest Cryptomarket.	Yes
Dark0de Reborn	26,718	Yes	No	Fast Growth.	Yes
The Canadian HeadQuarters	17,328	Yes	No	Canadian Market. Exit scammed.	
World Market	12,507	Yes	No	Fast Growth.	Yes
Versus	9,909	Yes	No	Decrease in Products.	Yes
ASAP Market	7,327	Yes	No	Slight Growth.	
Invictus	5,290	Yes	Yes	Exit scammed.	
CannaHome	3,596	Yes	No		
Corona Market	3,035	Yes	No		
Cypher Market	2,995	Yes	No		
Cartel Marketplace	2,746	Yes	No		
Cannazon	2,035	Yes	No	Only Sells Cannabis.	
Televend	Over 1,596	Yes	No	Seized.	
Monopoly Market	655	Yes	No		
Tor Market	383	Yes	No		
Babylon*	166	Yes	Yes	Allows Firearms	Yes.
DarkMarket	0	N/A	N/A	Seized.	
Silk Road 4	0	N/A	N/A	Exit scammed.	
Aurora	N/A	Yes	No	Exit scammed.	
ToRReZ Market*	N/A	Yes	No	18,121 products.	Yes
Neptune Market	N/A	Yes	No	Exit scammed.	
Yakuza Market	N/A	Yes	Yes	Allows Firearms	Yes
DarkFox Market**	N/A	Yes	No	28,138 products.	Attempted
Hydra	N/A	Unknown	Unknown	Not in English.	
Tor2door Market	N/A	Yes	No	7,433 products.	
MegaDarkNet	N/A	Unknown	Unknown	Not in English.	
Daeva	N/A	Yes	No	Onion site not found.	
Flugsvamp 3.0	N/A	Unknown	Unknown	Not in English.	
Enigma	N/A	N/A	N/A	Onion site not found.	
Yellow Brick	N/A	N/A	N/A	Onion site not found.	
BigBlue Market	N/A	N/A	N/A	Onion site not found.	
WeTheNorth	3,785	Yes	No	Canadian Market.	Yes

\*Minor technical difficulties.

\*\*Significant technical difficulties.

Next, two of the three cryptomarkets that allowed firearms were collected; Yakuza and Babylon. Yakuza was a mid-sized cryptomarket with 5,675 listings in January 2021, Yakuza was inaccessible in March, so there was no estimated number of products listed. Babylon was a small cryptomarket with only 166 listings in March 2021. The third cryptomarket, Invictus, exit scammed and could not be collected. Invictus was a mid-sized cryptomarket with 5,290 products, larger than Babylon and slightly smaller than Yakuza. After re-examining all inaccessible cryptomarkets in September 2021, DarkFox Market and ToRReZ were identified to be mid to large sized cryptomarkets which can further our understanding of the cryptomarket ecosystem and were scheduled for data collection. DarkFox could not be collected due to technical issues relating to the interaction between DarkFox and The Dark Crawler (TDC), the tool used to collect data.

Other cryptomarkets experiencing technical difficulties included Babylon and ToRReZ. Babylon would not allow the crawlers to gain access to the vendor profiles. This issue was unique to Babylon and likely has to do with how the cryptomarket was coded. All vendor data on Babylon were collected from listings. ToRReZ was under DDoS attacks during data collection, which significantly slowed data collection. WeTheNorth was added to the cryptomarket list in January 2022 because it was the only Canada-specific cryptomarket that was still available and may provide insight into the drug trafficking facilitated by cryptomarkets in the Canadian context. It was also the only active cryptomarket that was Canada-specific.

**Table 3.2 Cryptomarket Descriptives**

<b>Cryptomarket</b>	<b>Appeared</b>	<b>Data Collection</b>	<b>Listings</b>	<b>Reviews</b>	<b>Vendors</b>
Versus	August 2, 2019	June 9 - July 8, 2021	9,853	14,291	341
White House Market	August 2019	July 12 - Aug 5 & Sept 7-22, 2021	52,109	412,869	1,557
ToRReZ	April 14, 2020	Oct 1 - Nov 18, 2021	67,661	241,511	1,643
Babylon	April 2020	Oct 7-8, 2021	720	37	75
Yakuza	May 3, 2020	July 19-20, 2021	2,603	6*	106
DarkOde	May 22, 2020	June 10-27, 2021	37,945	39,755	1,575
World Market	November 14, 2020	Sept 23-30, 2021	24,032	129,276	586
WeTheNorth	July 9, 2021	January 28-29, 2022	3,785	3,259	164
<b>Total:</b>			<b>200,507</b>	<b>841,004</b>	<b>6,047</b>

\*No reviews were found. Sales were used in place of reviews.

Table 3.2 provides an overall view of when each market was collected and what was found on each cryptomarket. The cryptomarkets were sorted by when they first

appeared, from oldest to newest. They each have a separate chapter listing the rules, size, type of products available, drug products, where products were sold to, and fentanyl or firearms listings when available. Versus was assumed to be the oldest cryptomarket, appearing early August 2019 while WHM appeared sometime in August 2019.

## **3.2. Equipment**

The tool used for data collection was a web crawler called The Dark Crawler (TDC) which was created by the International CyberCrime Research Centre (ICCRC) at Simon Fraser University to access the dark web and collect data. TDC contained six crawlers on password protected virtual machines that would access cryptomarkets and collect all accessible pages to send to a secure database in the ICCRC lab. The ICCRC lab was physically protected by fob access in a secure section of Simon Fraser University. The crawlers would be connected to SecureVPN when accessing Tor for additional protection in case there were attempts to find the crawlers' IP addresses.

## **3.3. Procedure**

One computer would be used to access the crawlers and monitor them. Six accounts would be created on the cryptomarket of interest. The crawl parameters were created and undesired sections were excluded, such as the forums and the log out function, by using the sections of the Uniform Resource Locator (URL) associated with the undesired section. TDC was set to avoid accessing forums, other sites, images, payment options, and all messaging functions that would result in interaction between the TDC and dark net users.

The crawlers would be manually logged into that cryptomarket using one of the six accounts and set to collect pages starting from the home page. When the crawlers ran into any Completely Automated Public Turing test to tell Computers and Humans Apart (CAPTCHA)s, the CAPTCHA would be solved manually. The frequency of CAPTCHAs depended on the cryptomarket. It was not possible to capture all the selected cryptomarkets at once because of the limited number of crawlers and the manual input necessary to solve CAPTCHAs. Instead, cryptomarkets were captured in quick succession. Once one cryptomarket was captured, the data collection of the next

cryptomarket could begin. If a cryptomarket became inaccessible during data collection, data collection would start on another cryptomarket and return to the first cryptomarket once it was accessible again. TDC crawled the eight chosen cryptomarkets over eight months, from June 2021 to January 2022.

TDC collected and found new pages from cryptomarkets by collecting all the links on a page and adding them into a queue. It explored the next link in the queue and collected links from there. This continued until there were no more links in the queue that had not been collected. The crawl was completed over multiple weeks or months with periods of inactivity in between for data collecting or in preparation for the next crawl. If a link was collected but the page was taken down before it could be accessed by the crawler, the page was not collected. The products, vendors, and review sections were crawled for information. Due to how TDC finds information and new pages, only vendors who had accessible listings could be found. Only information that was available on accessible pages could be collected. Information such as the vendor's IP address, real names, and any specific location the vendor ships from that was not posted by the vendor on their profile page or listings could not be found.

Once the TDC had collected all the pages in its queue and could no longer find more pages, rules would be created to extract the data into different sheets for vendors, products, and reviews for each market. Rules would be the pathways to access information on each page that was collected during data collection. Rules are cryptomarket specific. For example, a rule would be created to find the name of the listing on all product pages for WHM. The pathway to the information would be inputted into TDC as a rule and it would collect all the information following the same pathway for all pages, even if it was not the listing name on the product page. On different types of pages, such as the vendor profile page, there may be information on the vendor and where they ship to. If it is available, the rule would output the vendor information from the vendor profile page in the same column as the listing name on the product page, on a different row.

Figure 3.1 is the raw data for vendor profile pages, yet column 2 with the URLs shows that there are listing pages and user pages. Different information appears depending on the type of page. Each page collected from a cryptomarket would go through the rules for that cryptomarket and all pages were outputted as a vendor,

product, and reviews when there was information following the same path. The extracted data was put into an Excel spreadsheet for further cleaning. On the vendor profile page sheet, reviews appeared in rows 9 to 19 instead of the vendor profile. Under column 3, where the vendor's profile content should appear, such as on row 21, the information for reviews appeared, such as the buyer's username, date, and review.

1	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9
2	Website	Pages	About	Disputes	Member sinc	Name	Number of d	Ships from	Ships to
3	http://pqqm	/listing/34069		Unlimited			France		
4	http://pqqm	/listing/33292		8			Greece		
5	http://pqqm	/listing/23416		Unlimited			India		
6	http://pqqm	/listing?cat=55&ipp=10&page=19					#000; background-color: r	p*****	
7	http://pqqm	/listing?cat=55&ipp=10&page=1					#000; background-color: r	f*****	
8	http://pqqm	/listing/33290		64			Greece		
9	http://pqqm	/user/9973594L*****'s P-			5/12/2020	L*****	31	United Kingd	Ships to:
10	http://pqqm	/user/0f82125U*****'s f-			4/11/2020	U*****	154	United Kingd	Ships to:
11	http://pqqm	/user/27b2ccep*****'s Feedbacks1 x Pregabalin 300mg x56 Mylan							Communication:
12	http://pqqm	/user/27b2cce d*****8							Communication:
13	http://pqqm	/user/27b2cce 2021-06-14							Communication:
14	http://pqqm	/user/27b2cce 77 VPStealth:once again delivered as promised. could not ask for anything mc							Communication:
15	http://pqqm	/user/27b2cce b*****i							Communication:
16	http://pqqm	/user/27b2cce 2021-06-15							Communication:
17	http://pqqm	/user/27b2cce 97 VPStealth:original insuline. very good communication with him. i alwa							Communication:
18	http://pqqm	/user/27b2cce a*****1							Communication:
19	http://pqqm	/user/27b2cce 2021-06-13							Communication:
20	http://pqqm	/listing/31680		Unlimited			China		
21	http://pqqm	/user/27b2ccep*****'s #000; backgr		#000; backgr		#000; background-color: rgba(51, 170, #000; backgr		20.00 EUR	
22	http://pqqm	/listing?cat=50&page=4					#000; background-color: r	N*****	
23	http://pqqm	/listing/3045		Unlimited			Germany		
24	http://pqqm	/listing/23553		0			Germany		
25	http://pqqm	/listing/35503		1			Germany		
26	http://pqqm	/listing/24406		0			Germany		
27	http://pqqm	/listing/32472		100			United States of America		

**Figure 3.1 Example of Raw Data Extracted from The Dark Crawler**

The relevant data for vendors, reviews, and products were separated into appropriate sections and cleaned for duplicates. Any scattered information where the values do not line up with the information from the market was removed. Rows with data from the incorrect pages would be removed, such as the reviews in rows 9 to 19 on the vendor profile spreadsheet. Duplicates were removed from the data. A listing or review was considered duplicate if the following matched: vendor name, product name, description, price, shipping location and destination, reviewer, review date, review, and if the payment was held in escrow. The price for all products were recoded into Canadian dollars (CAD). Not all cryptomarkets contained all the information by default, in which

case, if all the available information for that cryptomarket matched, it would be considered a duplicate. The remove duplicates function from Excel was utilized to remove duplicates from the data. When there were contradictions in the number of products sold or listed between the vendor profile and the listings themselves, the listing information was used instead of the information on the vendor profile page.

### **3.4. General Coding**

Coding the categories for the products and reviews was done manually with the use of the search and replace function in Excel. The main category a product falls under was recoded to be uniform throughout all eight cryptomarkets for cross market analyses.

- “Counterfeit” includes fraudulent currency and fake gold bars.
- “Drugs” includes drugs and physical drug related items, such as paraphernalia but excludes digital listings related to drugs.
- “Digital” includes products that can be digitally sent to the buyer. This category is the broadest category and includes database information from a hacked company, credit card and bank information, tutorials, and account information.
- “Forged Items” is primarily composed of physical fraudulent identification and documents.
- “Luxury Items” include primarily counterfeit luxury goods such as clothing, jewelry, accessories, and perfume.
- “Firearms” includes firearms and firearm related products such as ammunition and parts of a firearm but excludes blueprints for 3D printed firearms.
- “Other” category includes all other physical goods. Some are weapons such as knives, tasers, brass knuckles and pepper spray, others are electronics; phones, SIM cards, Wi-Fi jammers, and earbuds.

### 3.4.1. Drug Coding

Drugs was the largest category and while there is no consensus on the drug types in literature (Hout & Hearne, 2017; Tzanetakis, 2018; Buskirk et al., 2016), the eight cryptomarkets collected had a few overlapping categories. The main categories included: benzos, cannabis, dissociative, ecstasy, opioids, prescription, psychedelics, steroids, and stimulants. Tobacco, weight loss and other drug products were added as additional subcategories. The specific drug was manually coded by searching for keywords and then examining any listings that could not be sorted by keyword searches. It was inductively coded by searching the drug name and contains all the drug products in Appendix A.

The amount of each drug product was identified by running the product name through two python programs. The product name often stated what type of drug product it was and how much was being offered. Any listings that were over 100 grams, on all cryptomarkets, were manually examined to ensure the amount listed was correct and to reduce potential skew. To test the accuracy of the two programs, 242 randomly selected listings from Dark0de were manually coded and compared to the results from the program, after the manual cleaning of listings of 100 grams or over. Dark0de was selected as the baseline because it was an average cryptomarket, not the oldest nor the newest, and the data was more readily available as the first cryptomarket crawled. Listings with insufficient data to determine the amount would be considered accurate if no result was returned. When the program found a range of amounts, it was considered accurate if it collected the smallest or greatest amount of the range. These two programs had an accuracy rate of 95% on the sample of 242 listings. With the cleaned data, each cryptomarket can be examined and compared to each other, then combined for an overall view of the cryptomarket ecosystem.

## **Chapter 4. Products on the Cryptomarket Ecosystem**

Individual cryptomarkets each have slight differences that set them apart from other cryptomarkets. Understanding these differences and characteristics of each cryptomarket is important to understanding the ecosystem that is built upon these markets. Yet, only examining individual cryptomarkets may result in missing information on the interactions and effects cryptomarkets have on each other. An overall analysis of the cryptomarket ecosystem could explain three essential topics in greater detail.

1) The migration of vendors and buyers as cryptomarkets shut down and which cryptomarkets vendors and buyers are more likely to utilize. Vendors were identified across cryptomarkets by username and some vendors could be found on multiple cryptomarkets. Using the date each vendor joined a new cryptomarket, the time of vendor migration could be identified and compared to other events occurring in the cryptomarket ecosystem, such as cryptomarket shutdowns. Combining the data from eight cryptomarkets allows for a better understanding of the characteristics, number, and scope of individual vendors shipping drug or high-risk products.

2) When products are examined across multiple cryptomarkets, trends and patterns can be identified by examining where certain products, specifically drugs, can be shipped to. Examining the drug products could show which drug package and vendor characteristics limit the vendor's ability to ship products internationally. This could be informative about what factors affect a vendor's decision to offer international shipping on drug products.

3) Finally, it allows for a more accurate estimation of the size of the cryptomarket ecosystem, and the number of products being shipped. It will help identify the scope and extent of trade on cryptomarkets, allow for an estimation of the revenue of cryptomarket administrators and vendors, and identify the incentives that may provide sufficient profit for the risk of conducting business on cryptomarkets.

Each cryptomarket will be examined individually first, then built upon with the data from other cryptomarkets to create a holistic picture of the English speaking cryptomarket ecosystem that thrives on the dark web.

## 4.1. Individual Cryptomarkets

Each cryptomarket differs from the others and contributes a different amount to the cryptomarket ecosystem. To understand the cryptomarket ecosystem, there must be an overview of the components of the ecosystem, the individual cryptomarkets. There were many similarities between the cryptomarkets, thus, only the most important aspects and the differences between cryptomarkets will be highlighted. More attention will be given to WHM because it was the largest cryptomarket and can be used to measure the growth of the largest cryptomarkets over time by comparing WHM's revenue to other cryptomarkets which were the largest market of their time, such as Dream market. Reviews were used because they were commonly available across cryptomarkets while the number of sales were not. Buyers are often encouraged to leave reviews in order to show if a vendor is trustworthy, therefore, reviews were used as indications of sales for each product. This is in line with other studies that consider one review to be the equivalent of one sale (Aldridge & Décary-Hétu, 2014; Zhou, Zhuge, Fan, Du & Lu, 2020).

### 4.1.1. Versus

Versus is the oldest cryptomarket that data was collected from, with its first Dread post being on August 2, 2019 (Witchman05, 2019). Similar to most other cryptomarkets (Bradley, 2019; Lane et al., 2018; Morselli, Giguère & Petit, 2007), Versus had banned the sale of fentanyl and weapons. Fentanyl products were searched for by keyword search of "Fent" or "Fentanyl". If the product listing or description explicitly stated the product contained fentanyl, it would be considered a fentanyl product. If the product did not indicate that it contained fentanyl, then it would not be included as fentanyl because it is unknown if there was any fentanyl. No fentanyl or firearm products could be found on Versus, implying that the administrators were able to effectively control the products on their cryptomarket and swiftly enforce the rules. Vendors who broke the rules could be banned or subject to a fee of at least \$1,000. Under these strict guidelines, vendors may have been more hesitant to pay the vendor bond and sell their products on a strict cryptomarket like Versus.

There were 341 vendors and 14,291 reviews found on Versus. Versus' reviews only contributed to 1.7% of the total reviews from the combined eight cryptomarkets. Of

Versus' reviews, 91.2% were of drug products. Stimulants contributed to 70.3% of the total drug quantity because of the large drug vendors who sold speed paste in bulk. Speed paste is a stimulant that's often sold cheaply and in large amounts, primarily by 24 vendors on Versus. Despite the large quantity of stimulants being sold, only 0.8% (105) purchases met Aldridge and Décary-Hétu (2016) definition of wholesale products costing \$1,000 USD or more. The location where products could be shipped to was unavailable on Versus. Only the location where the vendor would ship a product from could be identified. Versus appears to be a slow and steady cryptomarket with firm control over their products. It has the potential to be a long-lived cryptomarket if they do not become a priority target for law enforcement.

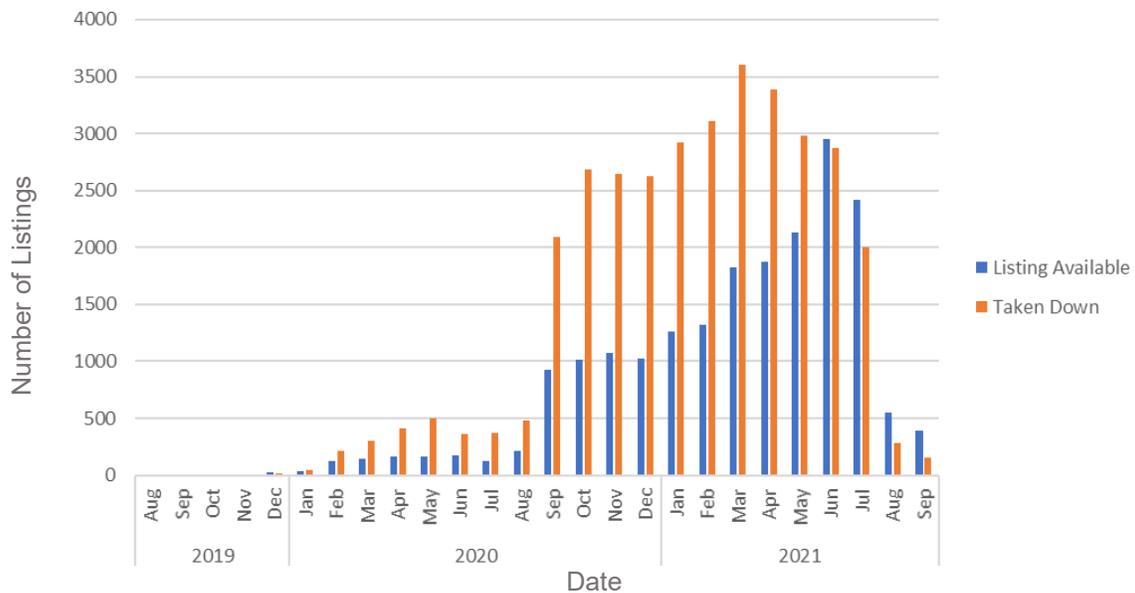
#### **4.1.2. White House Market**

White House Market became the largest English-speaking cryptomarket after Dark Market was seized by law enforcement in early January 2021 (Dark Market, 2021). On October 1, 2021, WHM's administrator (Mr.white) announced that they would retire because they had reached their goal, and that users would have a chance to withdraw funds from the market before the site was shut down (Mr.white, 2021). It is unknown what their goal was, however, it was likely financially motivated and they considered the risk required to maintain the cryptomarket compared to the potential profit. The administrators may have set out a certain amount of profit they wanted from the cryptomarket and had reached their mark or have determined that they were too high a priority for law enforcement and running WHM was no longer worth the risk. The administrator appears to have weighed the potential benefits and risks of operating WHM and found the risks to have outweighed the benefits, so they shut down a week after their announcement. As a larger cryptomarket, it was easier for Mr.white to earn more, however that does not necessarily mean they will facilitate more transactions. The larger the average pay for each crime during a period of time, the less frequently the offenders will commit crimes (Nguyen et al., 2022). Cryptomarket administrators respond to income from illegal activities similarly to other offenders.

WHM had banned fentanyl and firearms, yet sales of fentanyl and blueprints of 3D printed firearms were still found. There were eight purchases of blueprints of 3D printed firearms and one purchase for the slide of a Glock 19 BB gun, however, there were no full, physical firearms sold on WHM. Blueprints may not have been considered

as firearms or in violation of their rules and the listing for the slide was removed after a review was left. Some of the reviews were found on the vendor's profile page and were of listings that had been removed from the market. The reviews on a vendor's profile did not have the product description and categories, price, shipping location or destination. Only the product name, review and review date could be found. The limited information increased the chance that reviews would be considered duplicates even when they were not. As for fentanyl, there were only two vendors who sold a combined total of 206 fentanyl products, indicating that WHM may have come to an agreement with the vendors to allow them to sell fentanyl because WHM was able to keep the market clean of other banned products, such as physical firearm products.

Since its inception, WHM has facilitated the sale of at least 412,869 goods and services by 1,557 vendors, contributing to 54.3% of all reviews across eight cryptomarkets. Figure 4.1 was created using reviews found on the vendor profile page. If there was a corresponding listing that was accessible, then it would be counted as an available listing. If the listing was removed or otherwise not accessible, it would be considered a listing that was taken down. Only listings with at least one review were included in Figure 4.1 because if a listing with no reviews was removed, there would have been no indications that it previously existed. After four months, a listing that had been reviewed at least once was more likely to have been removed than to remain accessible. Listings may have been removed because they were outdated, the vendor ran out of stock on a product, or the vendor decided to stop selling that product. In June 2021, the number of listings that had been taken down was nearly identical to the number of listings still available. In May 2021, there was a large gap with many more listings removed than those that remained. Using data that only appears on listings will be less accurate after four months because over half the listings would have been removed.



**Figure 4.1 WHM Count of Listings Available and Removed by Date**

June 2021 was used to estimate the total revenue of the cryptomarket and its' vendors because data collection started in July 2021 and concluded in September 2021 with a period of time in between in an attempt to reduce the number of times the crawlers ran into CAPTCHAs. If the month of July or after was used, then it may be missing data and reviews of vendors and products because the page was previously collected. If a month before June 2021 is used, then there would be a greater chance that the listing was removed, possibility reducing the accuracy of the revenue calculation. All the reviews of June 2021 were tallied up and it was found that 38,552 out of 58,671 reviews still had a price available and totalled \$8.5 million. It was assumed that the average price for all the available listings was similar to the ones taken down. The average cost per review was multiplied by the total reviews to get an estimated amount of \$12.9 million for a total of \$154.5 million flowing through WHM at its peak, annually. This estimate does not take into consideration the number of sales that did not result in a review. The buyer may decide against leaving a review after buying a product, making it difficult to identify the total number of sales and implying this is a conservative estimate.

### 4.1.3. ToRReZ

ToRReZ was a cryptomarket that first posted on Dread on April 14, 2020 (ToRReZ, 2020). During data collection, WHM announced they would be retiring because they had reached their goal and that sparked DDoS attacks on the largest

cryptomarkets, including World market and ToRReZ, to disrupt their businesses. ToRReZ was attacked and data collection slowed down during the DDoS attack, requiring the collection period to take over a month from October 1 to November 18, 2021. ToRReZ was able to recover from the DDoS attacks and became the second largest cryptomarket in the dataset with 241,511 reviews and 1,643 vendors. There was a spike in vendors joining ToRReZ in October 2021, when WHM shut down, indicating that many vendors from WHM joined the next largest cryptomarket. Two months after WHM shut down, ToRReZ announced that they would shut down on December 30th, 2021, at 14:30 UTC (ToRReZ Market, 2021).

ToRReZ had banned fentanyl and firearms, yet, they had a large number of fentanyl sales, contributing to 49.9% (n=207) of the total fentanyl purchases across eight cryptomarkets. An overwhelming majority (99.5%) of the sales were fentanyl patches, one sale of fentanyl lollipop, and there were no purchases of carfentanil. Fentanyl patches may be preferred because they are convenient to use, has a longer effect period, and the dosage per patch is clear (The Recovery Village, 2020) compared to fentanyl in other forms such as in powder form. Fentanyl patches are likely considered less dangerous than powdered fentanyl, making them more popular and likely to be permitted on cryptomarkets. There were no physical firearms found, however, there were three purchases of blueprints for a 3D printed Glock 17. ToRReZ may have either allowed vendors to sell different forms of fentanyl, or not have as strict control over their cryptomarket compared to other cryptomarkets. There were no physical firearms, implying ToRReZ can control the products available on their market. It is possible that ToRReZ found the fentanyl vendors to be trustworthy and allowed them to sell their products on ToRReZ. The locations where products were shipped from and could be delivered to could not be identified in the data.

#### **4.1.4. Babylon**

Babylon was a small cryptomarket that likely appeared in April 2020 (Babylon, 2020). There were 37 reviews, 720 listings, and 75 vendors found on Babylon. It had an inactive forum on Dread that had not posted or updated since 2020. Babylon banned firearms, fentanyl, and had more rules banning specific products, such as GHB and flunitrazepam, however, those rules did not seem enforced. 1.4% (10) of the listings were of fentanyl or firearms, making it the cryptomarket with the second largest

proportion of fentanyl and firearms. The market administrators seemed indifferent to these rule violations and that may cause the potential buyers and vendors to worry that the administrators would not be capable of resolving disputes. All these factors may contribute to limiting the pool of vendors and buyers on Babylon.

#### **4.1.5. Yakuza**

Yakuza was a small cryptomarket that first posted on Dread on May 3, 2020 (Yakuza Market, 2020). It was the only cryptomarket that did not ban fentanyl and firearms, in fact, they explicitly allowed the sale of firearms and placed conditions upon their sale. The firearm must include a piece of paper with the vendor's username and "Yakuza Market" to confirm that it is the vendor's product. Allowing the sale of often banned products secures a pool of buyers interested in buying these and vendors who have access to those products and are willing to sell them. Yakuza contained 2,603 listings, 6 sales and 106 vendors. Yakuza had no reviews, however, there were several products that the market marked as sold. Each previously sold product was included once in the ecosystem spreadsheet to give Yakuza representation. There were six products with sales from Yakuza.

There were 12 custom listings, all firearm listings, when the vendor lists a product that was personalized for an individual buyer. For a custom listing to appear, the vendor and buyer must communicate and come to an agreement on what product is sold where and at what price. Once the two parties come to an agreement, the vendor will post the listing and state that it is a custom listing for an individual buyer. The buyer purchases the listing and after the product arrives, the money would be released to the vendor and the listing would be taken down. Removing the listing often also removes most, if not all, evidence of a sale if there was no review. There may have been a greater volume of custom listings that were taken down once the individual buyer had purchased the listing and the cryptocurrency was sent. The method of data collection used in this study would not adequately show the number of products that are sold to individual buyers because these products may only be available for a short period of time before they are taken down. It is unknown how long custom listings tend to be available for.

If the vendor and buyer communicated before placing a custom order, then it can be assumed that there is intent to purchase the product. Out of 12 listings, only 3 were

marked as sold and each listing was only sold once. Only firearm products had custom listings on Yakuza, indicating that listings of a sensitive or risky nature may be treated with greater caution and care to reduce the amount of evidence left behind from the sale. In addition to this, the majority of vendors (72.7%) selling fentanyl or firearms did not state where they could ship products from.

#### **4.1.6. Dark0de**

The earliest known post for Dark0de on Dread was on May 25<sup>th</sup>, 2020 (Dark0de Reborn, 2020), and the first vendor joined in May 2020. Dark0de had banned fentanyl and firearms from the cryptomarket and has been successful in keeping fentanyl and firearms off the market. There was only one review of a fentanyl listing by a vendor who left Dark0de before their profile could be collected, likely because they were banned from the market sometime during data collection. There were three reviews of blueprints for 3D printed firearms, however, they may not be considered weapons or firearms by the market and therefore do not violate Dark0de's rules. Including those three reviews, there were 39,744 reviews found on Dark0de and 1,575 vendors. The vendors on Dark0de could be selected from a drop-down menu. All vendor names and profiles were manually inserted into TDC's queue, therefore, there were no missing vendors from Dark0de.

There were spikes in the number of vendors joining in late August 2020, mid October 2020, and a general increase throughout January 2021 with a larger spike mid to late January. All of these spikes can be correlated to when a cryptomarket shut down, either by law enforcement or by choice. Empire market exit scammed in August 2020 (Empire Market, 2020), Deep Sea market exit scammed in October 2020 (Dark.link, 2020), and Dark market was seized by law enforcement in January 2021 (Dark Market, 2021). Dark market was the only time when there was a large spike in the number of vendors joining, possibly because Dark0de was considered a small cryptomarket before and vendors did not consider it a trustworthy cryptomarket when there were options that offered more visibility like WHM. By the time Dark market shut down, Dark0de became a larger cryptomarket and it was more likely that vendors who were willing to sell products on WHM already had an account. Thus, more vendors created accounts on Dark0de when Dark market shut down rather than before.

#### **4.1.7. World Market**

World market was the second youngest and third largest cryptomarket with 129,276 unique reviews and 586 vendors. It first posted on Dread on November 14, 2020 (World Market, 2020). It stated the total number of sales on each listing, allowing for a more accurate estimate of the total number of products sold through the cryptomarket ecosystem and examination of if the buyers of certain products do not tend to leave reviews. World market had 221,337 sales. The number of sales that result in a review can be calculated and applied to the annual estimate of the revenue and number of products sold on cryptomarkets. World market banned services meant to harm others, however, they did not explicitly ban fentanyl from the rules that were observed. Despite this, there were no fentanyl listings that could be found, so the market may have informally banned it.

World market had a larger percentage of digital purchases compared to all the previous cryptomarkets in the dataset, with 32.2% of purchases being digital and 67.6% as drug products. The vendors had a greater percentage of drug products able to ship worldwide (43.3%), yet, had fewer wholesale products than average (0.7%). Vendors on World market may be newer compared to older vendors on other marketplaces and feel the need to build up a good reputation. If older vendors are already established, then increasing business by taking on risks and shipping a greater number of products worldwide could offer them the opportunity to gain more reviews and seem more reliable if they are able to successfully ship products. They are still cautious to avoid shipping expensive shipments that may harm their business if caught, this allows them to minimize risk while attracting a greater number of buyers all around the world.

#### **4.1.8. WeTheNorth**

WeTheNorth (WTN) was the newest Canadian cryptomarket that specializes in products shipped within Canada. It was a small cryptomarket with 3,259 reviews for 164 vendors. The market stated the number of sales per listing, and WTN had a total of 6,661 sales. Canada Headquarters (CanadianHQ) was the last Canadian cryptomarket and was shut down in June 2021 (CanadaHQ, 2021). Within a month, WTN announced their appearance with a welcome message on Dread on July 9, 2021 (WeTheNorth, 2021). WTN only allowed Canada specific products on their market and stated that drug

products cannot be shipped outside of Canada. Outside of the country specific rules, WTN had banned fentanyl and firearms as well. No firearms or fentanyl products were found on WTN, implying that the cryptomarket administrators had the ability to enforce the rules and vendors follow the rules.

Vendors on WTN primarily joined in July 2021, after CanadianHQ shut down. There was no sudden influx of vendors when WHM and ToRReZ shut down, either because WTN is a smaller cryptomarket that was not as attractive as other cryptomarkets, or the vendor population is more specific to Canada and other vendors were not as interested in the cryptomarket. WTN vendors tended to sell more digital products than drug products. 76.3% of WTN's reviews were for digital listings. WTN had few drug listings and even fewer reviews of drug products. Drug reviews only made 22.8% of the total number of reviews, significantly less than the number of digital goods. Opioids were more popular on WTN than on other cryptomarkets. 31.0% of drug purchases were of opioid products and they were the category that generated the greatest revenue for vendors and the cryptomarket, contributing to 44.3% of the total drug revenue. WTN had very few cannabis purchases compared to other cryptomarkets, likely because cannabis is legal in Canada and there is no need to order from cryptomarkets to obtain a high-quality product.

None of the listings had any information on where they could be shipped from and delivered to, however, the rules stated that no products can be shipped from outside of Canada. It was assumed that all products were shipped within Canada. WTN had 3,785 listings, 2.2% (n=86) of which were custom listings. Each listing had information on the number of sales the listing had. Some of the listings could not be properly sorted into a category because the listing only contained the first and last letter of the buyer's name and was described as containing what was discussed between the buyer and vendor.

## **4.2. Products and Categories**

The reviews from all cryptomarkets were combined to get a sense of the total cryptomarket ecosystem of purchased products. The main category was uniformly coded as drugs, counterfeits, digital goods, luxury items, firearms, physical forgeries, and other physical products. The other listings included Wi-Fi jammers, parcel lockers, weapons

other than firearms, vendor equipment and electronics. These categories were combined because they were not of interest and were physical. There were only 289 products sold in the “Other” category by 18 vendors.

The types of categories do not include tip jars because tip jars do not indicate a vendor’s ability to sell different types of products. Tip jars are listings which do not sell products but serve as a means for buyers to donate a few dollars or tip the vendor. If an individual only sold drug products and tip jar listings, they would only fall under the drug category. The tip jar was not included in digital products or any other category. Occasionally, a review on the vendor’s profile page may have been left that indicates the product was previously available, then was taken down. These listings were also excluded because they have listings that belong in other categories, such as drugs or digital listings. This reduces the inflation of the number of categories a vendor has reviews in.

Babylon had very few reviews and Yakuza had few indications of sales. Due to the small sample size, they may not be good indicators of what was often bought on their respective cryptomarkets. Babylon only had 37 reviews and Yakuza had six sales, three of them were custom firearm listings. Table 4.1 shows the percentage of products by reviews across eight cryptomarkets, ordered by age.

**Table 4.1 Reviewed Product Category Percentaged for Eight Cryptomarkets**

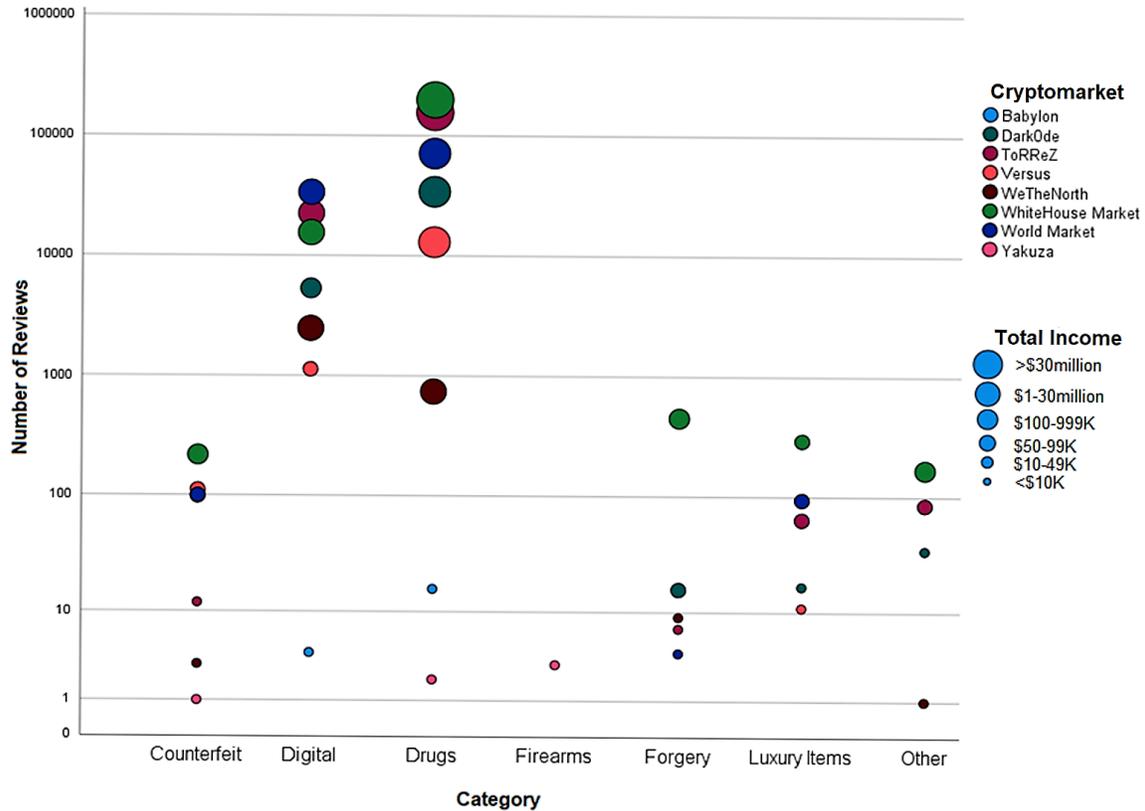
Vendor	Counterfeit	Digital	Drugs	Firearms	Forged Items	Luxury Items	Other	Total N
Versus	0.8%	7.9%	91.2%	0.0%	0.0%	0.1%	0.0%	14,291
WHM	0.1%	7.4%	92.1%	0.0%	0.2%	0.1%	0.1%	216,426
ToRReZ	0.0%	13.2%	86.7%	0.0%	0.0%	0.0%	0.0%	180,254
Babylon	0.0%	10.8%	89.2%	0.0%	0.0%	0.0%	0.0%	37
Yakuza	16.7%	0.0%	33.3%	50.0%	0.0%	0.0%	0.0%	6
Dark0de	0.2%	13.5%	86.1%	0.0%	0.1%	0.0%	0.1%	39,755
World Market	0.1%	32.2%	67.6%	0.0%	0.0%	0.1%	0.0%	105,405
WTN	0.1%	76.3%	22.8%	0.0%	0.0%	0.0%	0.0%	3,259
Total	0.1%	14.7%	84.9%	<0.1%	0.1%	0.1%	<0.1%	559,433

Drug products often took up the largest percentage across six cryptomarkets, totalling 84.9% of all reviews. Digital products came in second, for a total of 14.7% with one cryptomarket selling it more often than drug products. World market and WTN were

the newest cryptomarkets and had more digital products purchased compared to the other markets, especially WHM and Versus. WHM and Versus first appeared on Dread in August 2019 as the oldest markets available in the data and had the fewest digital products purchased. ToRReZ and Dark0de were neither the oldest nor the newest cryptomarkets and had the closest to average numbers of digital listings. This may be due to three possible reasons:

1. WTN and World market were the more recently created cryptomarkets and because there is more data available from cybercrime, there will be more digital listings posted on cryptomarkets. If this is true, cryptomarkets should expect to see a steady increase in the number of digital products compared to drug products.
2. Cryptomarkets have a greater number of digital products when they first appear because drug vendors are more hesitant to use new cryptomarkets without other vendors and buyers proving that the market is trustworthy. If this is true, then World market and WTN should expect to see an increase in the number of drug products compared to digital products.
3. WTN may have fewer drug products as a reflection of Canada because there are fewer drug products being shipped domestically within Canada compared to the rest of the world. WTN had a rule stating that products could only be shipped within Canada and be Canada related. Due to that restriction, WTN may have had a greater focus on digital products.

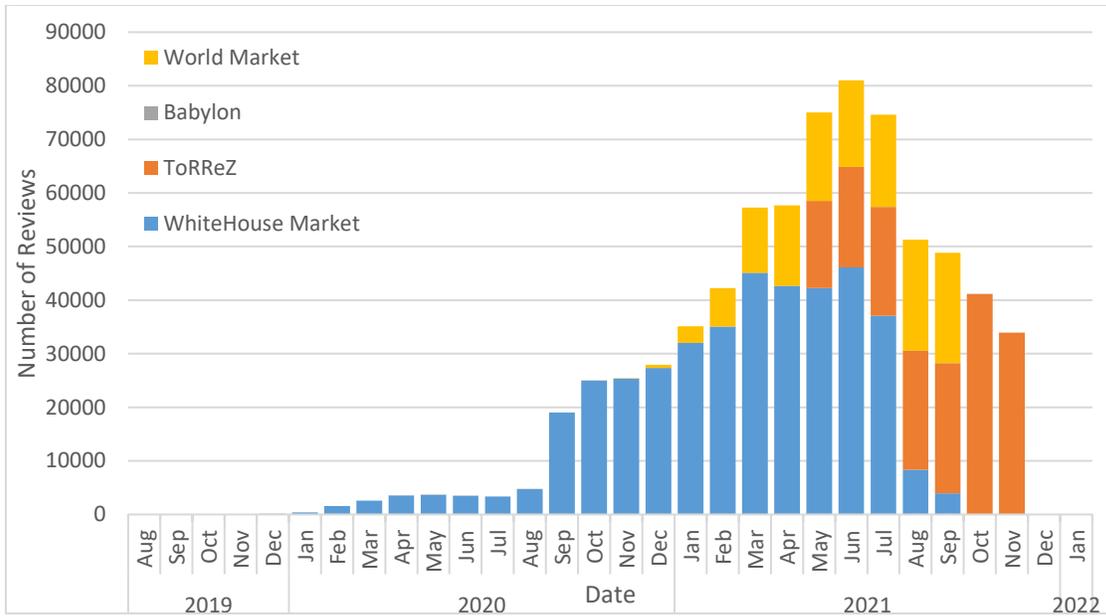
The difference in cryptomarkets by the number of listings, sized by the total price, in each category is laid out in Figure 4.2. WHM had the greatest number of reviews in all categories except digital goods and firearms. WHM had more income from digital products than ToRReZ and World market despite WHM having fewer reviews. ToRReZ and World market had more reviews in the digital category at a cheaper average price than WHM. ToRReZ was a close second to WHM in regard to the number of drug reviews and the total income from drug products. It is the next second largest cryptomarket behind WHM. World market, while having the second smallest percentage of drug reviews, had the third largest sum of drug cost and reviews. In luxury items and digital goods, World Market was a close second to WHM in terms of revenue.



**Figure 4.2 Scatter graph of Product Category and Price by Cryptomarket**

### 4.3. Revenue Estimation

There were 841,004 unique reviews for 2,864 vendors, across Versus, WHM, ToRReZ, Babylon, Yakuza, Dark0de, World market, and WTN. 618,643 product reviews had a price, for a sum of \$111.1 million. 3,825 unique vendors were found across the eight cryptomarkets, 961 of which had no sales or reviews on any cryptomarket. June 2021 had the greatest number of reviews which were still available and will be the month used to calculate the total income of cryptomarkets and all their vendors. Earlier months, such as in 2020 or early 2021, were not ideal because listings were more likely to have been removed than remain available. Later months, such as August 2021 or after, were not ideal to examine for overall sales because data collection was well underway or completed for some cryptomarkets. Sales can take time to finalize and that may cut down on the number of reviews available in that month, if the cryptomarket had not been collected or the entirety of the month would be missing from a cryptomarket because it was already collected.



**Figure 4.3 Number of Reviews Found by Month**

The average price per listing, of the listings with a price, was multiplied by the number of reviews in June 2021. At their combined peak, World market, Babylon, ToRReZ and WHM had a total income of \$15.5 million monthly income for vendors and the cryptomarket based on the number of reviews. However, there is a percentage of sales that do not result in a review. To estimate the number and extent of sales more accurately on cryptomarkets, the sales to review ratio was created. The sales to review ratio was created to account for the number of sales where the buyer did not leave a review. Versus, ToRReZ, World market, and WeTheNorth contained information on the number of sales and reviews. The number of reviews were added up and divided by the total number of sales. It was found that 55.0% of sales resulted in a review.

The estimate does not consider the specific categories that may have fewer reviews compared to sales, such as firearms. Some sensitive categories may have fewer review due to users having little to no desire to leave a digital footprint. The sale to review ratio could not be created for each category and used in the overall estimate. The estimate may be skewed towards less sensitive products. Estimating the income by the average cost of a listing multiplied by the number of reviews and accounting for the sales to review ratio, the four cryptomarkets and their vendors had an estimated monthly income of \$28.3 million.

The commission fee of three cryptomarkets were found. WHM and World market had a 4% commission and ToRReZ had a 5% commission (Dark Net Stats, 2022). An average of 4.3% will be used when calculating the cryptomarkets' income. The cryptomarkets had an estimated income of \$1.2 million in June 2021, and vendors had a total income of \$27.1 million. 11.5% of cryptomarket reviews were in June 2021. To include other cryptomarkets, it was assumed that the percentage of sales that occurred in June 2021, was similar across all cryptomarkets. Annually, buyers bought an estimated 2.1 million products for \$378.5 million across Versus, WHM, ToRReZ, Babylon, Yakuza, Dark0de, World market, and WTN. These eight cryptomarkets had an income of \$16.3 million annually, assuming commission was 4.3%. Each cryptomarket likely has one administrator, plus a few moderators that the administrator will pay if the cryptomarket is too large for the administrator alone to handle. The annual income of a large cryptomarket administrator could be in the millions, making this a lucrative business.

#### **4.4. Discussion**

Research question 1 argued that cryptomarket administrators make a sufficiently large profit which may encourage them to continue to operate cryptomarkets and facilitate the trade of illicit goods and services. Eight cryptomarkets and their vendors earn \$378.5 million from sales each year. This dataset did not contain all of the largest and medium sized cryptomarkets, so it could not be considered the total revenue of the entire cryptomarket ecosystem. The real revenue generated by cryptomarkets is likely much greater. A single large cryptomarket on par with ToRReZ or World market would likely contribute another \$80-100 million to the annual estimate. Smaller cryptomarkets may not make a large difference in the expected total after rounding. From our cryptomarket list, it would be expected that DarkFox and perhaps CanadaHQ would have been considered a large cryptomarket. It is likely that the actual annual revenue generated from all English speaking cryptomarkets is closer to \$550 million. While it is difficult to get a full sense of how much revenue is generated by the cryptomarket ecosystem for the cryptomarket administrators and vendors, growth can be measured across markets by using the largest cryptomarkets of their time.

Dream market was the largest cryptomarket for a period of time, and the cryptomarket administrator and vendors had an estimated monthly income of \$17.8

million CAD in 2019 (Zhou, Zhuge, Fan, Du & Lu, 2020). WHM was the largest cryptomarket in 2021 with an estimated monthly income of \$12.9 million before accounting for the number of sales that did not result in a review. After accounting for the sales to review rate, the total income of both vendors and the cryptomarket increased to \$23.5 million. WHM had a 4% commission rate, earning the cryptomarket administrator \$938,182 in June 2021, yielding WHM's administrator an estimated annual \$11.3 million in revenue. WHM earned 32.2% more than Dream market and 247.5% more than Silk Road (Aldridge & Décary-Hétu, 2014; Zhou et al., 2020). The largest cryptomarket grew by 32.2% in past three years. This size of the cryptomarkets is expected to continue to increase over time as more people use technology and as more products move onto cryptomarkets, possibly by a similar percentage year over year.

Cryptomarkets can be extremely profitable for the administrators, earning them an estimated annual income of \$16.3 million across eight cryptomarkets. The profit of being the cryptomarket administrator of a mid or large sized cryptomarket is a large amount and may provide sufficient incentive to individuals with the capabilities to open new cryptomarkets, to try their hand. Small cryptomarkets may not generate sufficient profit to attract many administrators, however, if the administrator is able to grow their market into a large cryptomarket, they may consider the potential profit to be worth the effort and risk of law enforcement intervention.

Administrators have the opportunity to learn from the mistakes of their predecessors and adjust their cryptomarket as needed. The list of factors administrators may consider when creating and changing their cryptomarket, their crime script, adapts with experience and as events occur (Clarke & Cornish, 1985). Cryptomarkets and their users may be especially quick to adapt with the changing cyber landscape. The professionalism to evolve in response to the community and incorporate new features, similar to software patches, can increase the longevity and competitiveness of their cryptomarket (Xu et al., 2017). This can attract vendors and buyers by showing that the administrator is interested in their cryptomarket, willing to listen to the community, and invested in the market.

Smaller cryptomarkets do not have as many vendors and buyers to start with, however, as they prove themselves trustworthy, there would be a greater amount of traffic on their cryptomarket. As the expectation for more professional cryptomarkets,

custom web pages, and better security measures increases (Xu et al., 2017), it may prove a barrier for newer and unexperienced cryptomarket administrators to become larger if there are other active cryptomarkets with those characteristics. New opportunities often arise as other markets shut down and users are forced to search for new markets to sell or purchase products from. When a cryptomarket shuts down, other cryptomarkets may offer vendors of the defunct cryptomarket a free vendor account to attract more vendors and grow the number of users on their cryptomarket.

There was support found for research question 1. If administrators are able to grow their cryptomarkets into mid or large cryptomarkets, then they can likely make a sufficiently large profit that would be worth the risk of running a cryptomarket. Cryptomarkets can grow larger with the administrator's effort and care, as they show themselves to be trustworthy. The longer a cryptomarket remains active, the more opportunities the administrator has to grow their cryptomarket larger. It is likely that the cryptomarket ecosystem will only continue to grow larger as more people willing to risk operating a cryptomarket recognise the opportunity and seek to profit.

## Chapter 5. Vendors

Across eight cryptomarkets, a total of 6,047 vendors were found, including duplicate vendors. There could have been vendors who had no active listings and were not found because there was no URL that led the crawlers to the vendor. Vendors often filled out the vendor profile with some information about their experience, when a product is expected to arrive, response times, if they were on vacation, and highlighted reviews. Cryptomarket vendors did not tend to disclose personal details about themselves, such as specific locations within countries that they shipped products from, names, or the number of people they worked with. To identify duplicate vendors across cryptomarkets, usernames were used. Not all vendors had a fingerprint key or Pretty Good Privacy key, however, vendor usernames were found on all cryptomarkets and could be used as a uniform metric to identify vendors.

Cryptomarkets allow vendors to join and retain their username from other cryptomarkets, going as far as to remove users or change the user's name if they used the same username as the original vendor. Duplicate vendors were searched for by removing the numbers at the end of a vendor's name, capitalization, spaces, and characters substituting for spaces would be removed. For example, BestDrugs123 and BestDrugs would have been considered the same user. Finally, usernames which were greatly similar to another user, such as Great\_Cookie, Great\_Cookies, and GreatCookiesOfficial, would have been considered one vendor. There were 3,825 unique vendors after combining duplicate vendors with different accounts. The top 16 (0.4%) vendors accounted for 10.2% of the reviews across eight cryptomarkets. The top 62 (1.6%) vendors accounted for 25.2% of all reviews, and 222 (5.8%) vendors accounted for half of all reviews on cryptomarkets. 662 (17.3%) of vendors accounted for 80% of the reviews on cryptomarkets. 961 (25.1%) vendors had no reviews. The majority of purchases were concentrated in a small percentage of vendors. Vendors on cryptomarkets follow the same trend as other offenders, where a small number of prolific offenders account for a large percentage of all crime (Tilley, 2013).

Some vendors had listed multiple physical locations where they would ship products from, available on their profile page and the listings they sold. The listings did not always offer the same information as the profile page. The information from the

reviews was included when examining where the vendor could ship from. For the analyses, if two locations did not contradict each other, the more specific location would be used. For example, if both North America and Canada were listed, Canada would be the location used because it was more specific than North America and is within North America. When the two locations were different, such as Canada and the United Kingdom, then the first location found would be used as the primary location and all other locations would be counted as the second, third, fourth and fifth locations where the vendor can ship from.

## **5.1. Vendor's Sale Process**

Once vendors have an account on a cryptomarket, vendors can list and describe the products they sell. Vendors often describe where they ship from, where they can ship the product, the cost of the product, any refund or reship policies they may have, the quantity of the product remaining, and other relevant details they wish to add, such as instructions for how to use the product and how long it would take for vendors to ship the product. Some cryptomarkets have advertisements on the front page where vendors can advertise their products for a fee. Some vendors may decide to advertise so buyers are more aware of their products and become more competitive.

Once the listing is posted, the vendor can wait for a purchase. If a buyer decides to purchase a product from the vendor, the buyer could pay for the order by placing the money into escrow. If they wanted adjustments to the order, they may communicate with the vendor to request a custom listing and buy that once the vendor listed it. Custom listings were rare, only 0.1% of reviews were for custom listings. Now that the buyer has shown their interest and intent to purchase the product, the vendor can send the order to the buyer. Physical products would be packaged and shipped, requiring a period of time between purchasing the product and the buyer receiving the product. During this time, the buyer can extend the time on escrow to prevent the vendor from gaining the funds.

There are times when a buyer does not receive the product they order. When this happens, the buyer can open a dispute and argue to the cryptomarket that they were scammed, and their money should be returned. Whoever the cryptomarket rules in favour of, will be sent the money. Some cryptomarkets have the number of disputes each user was involved in and the number they have won and lost. This can affect the

vendor's reputation negatively if they have many lost disputes or positivity if they have few to no disputes or have won the majority of those disputes.

If the buyer has received the product and is satisfied, they release the money in escrow to the vendor. The deal is finalized once the money is released because the cryptomarket no longer has control over the money and cannot facilitate refunds. The buyer can now make a review detailing how satisfied they were with the product and vendor. These reviews affect the vendors' reputation. Vendors with good reputations are considered more trustworthy and less likely to scam buyers, therefore they would be more likely to attract buyers than those who are without a good reputation.

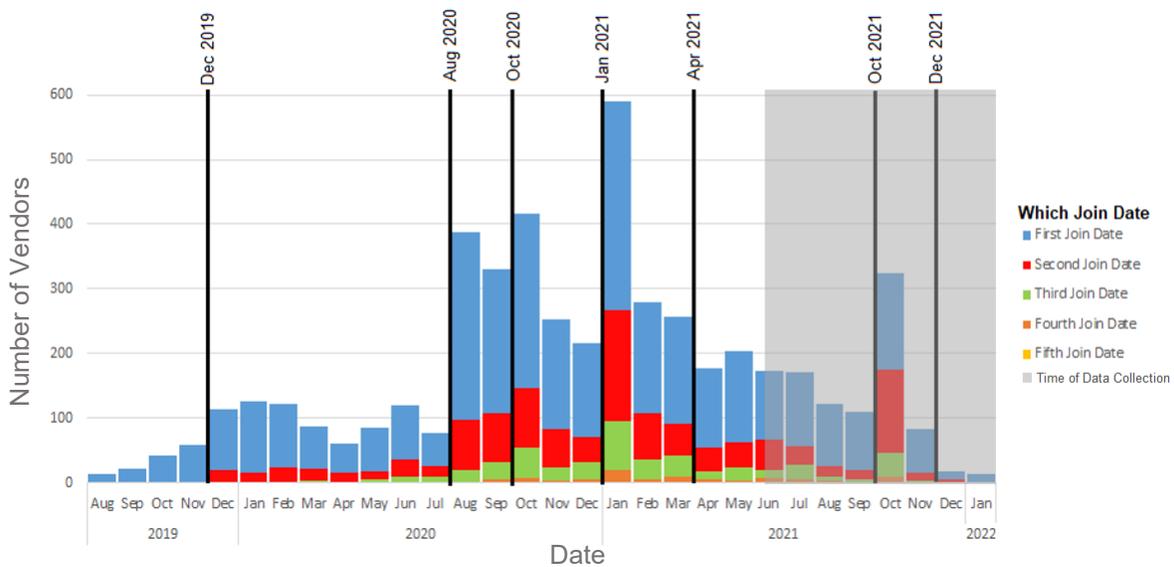
## **5.2. Vendor Join Dates Across Cryptomarkets**

3,825 unique vendors were found across eight cryptomarkets. 63.5% (n = 2,432) of vendors only had an account on one market. 710 vendors had accounts on two markets, 345 on three markets, 176 on four and 49 on five cryptomarkets. The majority of vendors appear to have had a primary cryptomarket they conduct business on, then migrate to other cryptomarkets if the cryptomarket is shut down. To examine vendors migration habits compared to cryptomarket shutdowns, Figure 5.1 was created to show when cryptomarkets were shut down and when vendors created a new vendor account. The vendor join date and the date cryptomarkets shut down were generalized to the first day of the month. The shutdowns were noted by vertical black lines.

After a large cryptomarket shuts down, in the same month, there is a sudden increase in vendors joining cryptomarkets. These vendors often join different cryptomarkets, however, there have been a few that have joined the same cryptomarket multiple times. 37 vendors had two accounts on the same cryptomarket, one vendor had two accounts on two cryptomarkets, and one vendor had 4 accounts on ToRReZ. In 25 cases, the join date differed between 13 days and 445 days. 131 days was the average number of days from the first join date on the cryptomarket to the second. The vendors may have decided to create a new vendor account and use the new account rather than the old one because their account had too many disputes or was offered a free account when the cryptomarket was attempting to attract more vendors. For three vendors, they joined with two accounts on the same day. There may have been an error with their original username or another user with that username was removed so the original

vendor could create a vendor account with their original username. In 11 cases, there was only one join date, and the second join date was missing. These cases may have been duplicate vendors whose names on the profile page and the product listing or review were slightly different.

Cryptomarket shutdowns prompt vendors to join more cryptomarkets. Empire data was not collected so none of the vendors on Empire were included in the analysis, yet there was an increase in second and third join dates. Vendors who may not have been on Empire still joined other cryptomarkets for the second or third time once Empire shut down. Even if vendors are already on multiple cryptomarkets, the shutdown still prompted them to explore more cryptomarkets where they could conduct business on. Large vendors may prefer to stay on at least a few cryptomarkets at once to reduce risk and disruptions to business when cryptomarkets are attacked or shut down.



**Figure 5.1 Vendor Join Dates Over Time**

Figure 5.1 shows that there were often spikes in the number of vendors joining cryptomarkets after a cryptomarket was shut down. Tochka marketplace exit scammed around the start of December 2019 (Tochka, 2019). Following that was a small increase in the number of vendors and the first few cases of a vendor joining a second cryptomarket from the data. In August 2020, the Empire Market experienced a DDoS and was unable to facilitate the sale of goods and services (Empire Market, 2020). During this attack, Empire decided to shut down and take the remaining cryptocurrency

still in escrow, exit scamming (Empire Market, 2020). The displaced vendors primarily migrated to WHM, with a few that migrated to other markets. Between early to mid October 2020, DeepSea Market exit scammed (Dark.link, 2020). During the same time, there was another increase in the number of vendors joining the market.

The largest spike in vendors joining was in January 2020, when Dark Market was seized by law enforcement. In January 2021, when Dark Market was seized (Dark Market, 2021), vendors took longer to join different cryptomarkets when compared to Empire Market and DeepSea Market shut down. Dark Market was the largest cryptomarket at the time and it had been available since May in 2019 (Caesar, 2021). If vendors were more established on a cryptomarket and have not needed to move, they may be out of date in what cryptomarkets are most profitable. This would imply that established vendors require more time to research the different cryptomarkets before joining. In October 2021, WHM announced they would shut down, then shut down a week later. There was a sudden increase in the number of second and third join dates in the cryptomarkets that had not been fully collected yet. In December 2021, ToRRReZ announced they would also be shutting down. They shut down on December 30, 2021. There was no large increase shown in the number of vendors joining because all markets, other than WTN, had been collected by December 2021.

It should be noted that not all market shutdowns cause a spike in vendors joining. For example, when Aurora market exit scammed in April 2021, there was not a significant increase in vendors joining other cryptomarkets. Aurora was a smaller cryptomarket and vendors may have considered it a backup market that they use in addition to their main accounts on other cryptomarkets. Aurora's shutdown would not impact as many vendors to the point where they decide to research which cryptomarkets are most profitable. When large cryptomarkets shut down, vendors rapidly migrate to other markets, primarily to other large cryptomarkets. Vendors have backup plans and are prepared for the event of a market closure or shutdown (Hout & Bingham, 2014). They are aware of the different cryptomarkets and have completed the research to determine if it is profitable beforehand or has decided to pick their backup plan.

### 5.3. Factors for Vendors Shipping Internationally or Not

There were some vendors who offered international shipping and some who did not. To identify what factors may influence a drug vendor’s ability or willingness to ship drug products internationally, Mann Whitney U tests were chosen to examine the time vendors had been on cryptomarkets, the number of drug reviews they had, the variety of products they could sell, and the number of cryptomarkets they were available on. A non-parametric bivariate test was selected because the variables were not normally distributed. The vendor experience variable was created by how long they had been on the market, in the number of days, since the last vendor joined. It is based on the first time a vendor was known to join any of the cryptomarkets in this study.

The drug review variable was based on the number of drug reviews a vendor had. It can be used as a measure of how successful the vendor was at selling their product. The variety of products was based on the number of categories the vendor had a sale in, which indicates the vendor’s ability to sell products in a category. The final variable is the number of cryptomarkets, from this study, that a vendor was identified on. 1,683 vendors did not offer international shipping while 637 vendors offered international shipping.

**Table 5.1 Factors Influencing if Vendors Ship Internationally**

Drug	Effect Size	Not International Median	International Median	U	z	N
Vendor Experience*	-0.20	453	514	344323	344323	2199
Drug Reviews**	-0.19	13	34	404939.5	404939.5	2320
Variety of Products*	-0.10	1	1	511356.5	511356.5	2320
Available on # of Markets*	-0.24	1	2	386530	386530	2320

\*Significant at  $p < 0.001$

\*\* Significant at 0.011

Table 5.1 shows that all four variables were significant. There was a significant difference in the time a vendor was on a market between vendors who offered to ship products internationally and those that did not ( $p < 0.001$ ). The effect size was small ( $r = -0.20$ ) for social sciences (Cohen, 1988). The median for vendors who shipped internationally was greater than the median for vendors who did not ship internationally. The number of drug reviews was significantly different between vendors who shipped internationally and those that did not with a small effect size ( $p = 0.001$ ,  $r = -0.19$ ). There

was a significant difference in the variety of products vendors who shipped internationally and vendors who did not ( $p < 0.001$ ,  $r = -0.10$ ). Finally, the number of markets vendors could be found on significantly differed between those who offered international shipping and those that did not ( $p < 0.001$ ,  $r = -0.24$ ).

## **5.4. Firearms, Fentanyl, and Major Drug Vendors**

Firearm and fentanyl products were high-risk products that may attract more attention from law enforcement. The vendors who sell these products require a higher-risk tolerance and likely have additional safeties to protect against the heightened risk. The top 20 drug vendors ship a great quantity of drug products, 1.3 tons, which could increase the risk they face as well. Firearm, fentanyl, and major drug vendors will be compared to the average vendor and examined to see if there are differences in their characteristics. Not all firearm and fentanyl vendors listed where they ship products from on their vendor profile. There were 24 out of 47 vendors with unknown shipping origins. To reduce this gap, the location of the firearm and fentanyl vendors included the vendor origin compiled from reviewed products. When there were contradictions, the product listing would be the one used. If there were locations within the other, such as the EU and Belgium, the more specific location was used. There were 17 unknown origins after including the location of other purchased products across all cryptomarkets.

### **5.4.1. Firearms**

Firearm related products included firearms, ammo, firearm parts, blueprints of 3D printed firearms and 3D printed firearms. In addition to firearms, there were three weapon listings offering M67 grenades, C-4 and an AT4 rocket launcher. All three were unsold and excluded from Table 5.2 because they were classified under the other physical products category. Rocket launchers are not rifles or handguns and generally are not thought about when talking about firearms. The number of sales next to the number of firearm and fentanyl related listings was created using the higher number of either the sales or reviews found on each cryptomarket for the products and added up per vendor.

**Table 5.2 All Cryptomarket Firearm and Firearm Related Listings**

Vendor	Location	Ships to	Number of listings (Sales)	Drug Reviews	Digital Product Reviews	All Reviews
10040	Worldwide	Worldwide	1* (4)*	92	2,663	2,992
10368	Bulgaria	Worldwide	1* (0)	554	317	1,156
11631	North America	Worldwide	1* (1)*	0	341	341
12019	Unknown	Unknown	1* (0)	0	2035	2281
13868	Canada	Digital	1* (0)	0	103	103
10076	Europe	Digital	2* (2)*	3	272	318
12280	Unknown	Unknown	2* (8)*	0	0	8
13246	Europe	Worldwide	3* (0)	0	0	0
12063	Digital	Digital	5* (3)*	0	176	225
10812	Canada	Unknown	1*** (1)***	3	0	107
13196	United States	Worldwide	1 (0)	0	0	0
13214	Unknown	Worldwide	1 (0)	0	0	0
13258	Unknown	Worldwide	1 (0)	0	0	0
13617	Germany	Unknown	1 (0)	0	0	0
13226	United States	Worldwide	2 (0)	0	0	0
13002	Germany	Worldwide	2 (0)	0	0	0
13230	United States	Worldwide	2 (0)	0	0	0
13238	Unknown	Worldwide	2 (0)	0	0	0
13632	United States	Unknown	2 (0)	0	0	0
13233	United States	Worldwide	3 (0)	0	0	0
13216	Unknown	Worldwide	4 (3)	0	0	0
13223	Unknown	Worldwide	4 (0)	0	0	0
13202	Unknown	Worldwide	5 (0)	0	0	0
13208	Canada	Worldwide	5** (1)*	0	0	1****
13221	Italy	Worldwide	6 (0)	0	0	0
11644	Unknown	Worldwide	16 (0)	0	0	3
12642	Australia	Worldwide	20 (0)	1	0	1

\*Firearm was digital

\*\*One product was digital

\*\*\*Firearm part

\*\*\*\*Only sales were included

There were only three physical firearm sales where the listing was still available. All three were custom listings on Yakuza by vendor 13216. The first listing was for two boxes of hollow point ammunition. The second was for four boxes of hollow point ammunition. The last listing was for four boxes of hollow point ammunition, a Glock 19 and two extended magazines. Vendor 13216 did not have accounts with a similar username on any other cryptomarket, implying that they specialise in firearm products and had little to no reason to join other cryptomarkets that would ban their products.

There was one review of a metal top slide for a Glock 19 BB gun replica on WHM, which had the listing removed by the time of data collection. There were ten vendors who listed blueprints for 3D printed firearms and sold 19 blueprints for 3D printed firearms. Seven of the ten had sold 5,907 other digital products as well. The majority of vendors selling blueprints for 3D printed firearms may see it as just another digital product alongside the rest of their items rather than firearm trafficking. One vendor only sold blueprints for 3D printed firearms and one vendor had physical firearms and blueprints for 3D printed firearms. Those two vendors specialising in weapons and blueprints did not have many visible sales.

Of the physical firearms 80.5% (62 out of 77) were for handguns: 45.5% (n=35) were Glocks and 10.4% (n=8) Berettas. Cryptomarkets have more handguns and handgun products than rifles and other long guns. 15.6% (12 out of 77) of physical firearm listings were custom listings. Custom listings are created when vendors and buyers communicate and agree on the details of a listing. The vendor would create a listing to the buyer's specifications and personalize it for an individual buyer. Some firearm vendors may only offer custom products and will not sell products without previous discussions with the buyer. Once the custom listing is purchased, there would be little reason to keep the listing active. The person the listing was created for already bought it and the only reason to leave it up is to state that the vendor had sold firearm products. It could serve as advertisement and increase the amount of trust the vendor has. The risk is that it could also make them a larger target to law enforcement. Vendors who only sell custom listings would appear to have few to no sales or reviews, making it difficult to track the number of products they sold. Custom listings, if they are not digital, will likely take a few days for the product to be shipped and delivered.

Cryptomarkets were generally intolerant to physical firearm products, except Yakuza and Babylon. Babylon had rules against the posting of firearm listings, however there was little moderation to ensure the rules were followed. Babylon had three unsold listings for handguns. ToRReZ, Versus, WTN, and World market had no physical firearms or firearm related listings. The two listings for Glock handguns on Dark0de, both unsold, were from a vendor that created their account recently and had no sales on any of their products. Dark0de was generally able to remove any fentanyl from their market, therefore, it is possible that the administrators had noticed the vendor violating the rules by posting firearm products. Most cryptomarkets do not allow physical firearms to be

sold on their sites and are generally able to remove any firearm listings. This pushes firearms off those cryptomarkets and onto other markets, such as Yakuza or single vendor stores that sell firearms.

Cryptomarkets were not examined over time, so it is likely that there would be fewer reviews and sales for firearm products because firearm products have a greater percentage of custom listings than most other products on cryptomarkets. There may be very few firearm sales to begin with and they happened to all be custom listings, however, it appears more likely that vendors are more cautious with sensitive products and wish to reduce their digital footprint. Each physical firearm product was sold once at most, which supports that vendors are aiming to reduce the amount of attention on them for selling firearm related products while still conducting a successful business.

There were studies that examined firearms on cryptomarkets, however, there were potential issues around the honesty of reviews and sales for vendor shops (Broadhurst et al., 2021; Copeland et al., 2019; Paoli et al., 2017). Paoli et al. (2017) monitored cryptomarkets and estimated that there were 91 physical firearms and ammunition products sold monthly. The estimate was created using data from 12 cryptomarkets collected in 6 days in September 2016 and did not continuously monitor the activity on cryptomarkets. To better estimate the number of firearm and firearm related products while accounting for the potentially faster turnover rate, consistently monitoring cryptomarkets with firearms and considering each custom firearm product a sale would allow for a more accurate estimation of firearm products being trafficked.

#### **5.4.2. Fentanyl**

There were drug products that may have been laced with fentanyl such as China White, M30s, and some fake prescription medication, however, they were not included because it is uncertain what does and does not contain fentanyl. Only products that stated they were fentanyl products would be considered a fentanyl listing in Table 5.3. There were 22 vendors selling 141 unique fentanyl listings. Eight vendors accounted for all 415 fentanyl sales. Sales included when vendors had a sale listed on a fentanyl product, yet had no review. 93.3% of fentanyl products were sold by vendor 11735. They were the only vendor with a significant portion of their income (18.1%) from fentanyl sales. 209 fentanyl purchases had a known quantity that was shipped.

**Table 5.3 All Cryptomarket Fentanyl Listings**

Vendor	Location	Ships to	Number of Fentanyl Listings (Sales)	Drug Reviews	All Reviews
11735	Belgium	Worldwide	96 (387)	1,321	2,403
11553	Worldwide	Worldwide	5 (1)	1	1
13240	Unknown	Worldwide	5 (0)	0	0
13712	Unknown	Unknown	4 (0)	0	0
11691	Netherlands	Unknown	3 (5)	95	106
10160	Netherlands	Unknown	3 (3)	731	802
12006	Italy	Worldwide	3 (2)	13	70
12624	Unknown	Unknown	3 (0)	7	8
13215	Unknown	Worldwide	3 (0)	0	0
13222	United States	Worldwide	2 (0)	0	0
13619	United States	Unknown	2 (0)	0	0
13623	United States	Unknown	2 (0)	0	0
10043	United States	Unknown	1 (13)	0	961
11318	Netherlands	Unknown	1 (3)	295	320
10274	Worldwide	Europe	1 (0)	1	7
11808	United States	Worldwide	1 (1)	1	1
12001	Unknown	Worldwide	1 (0)	1	1
12516	Unknown	Unknown	1 (0)	9	16
13247	Unknown	Worldwide	1 (0)	0	0
13602	United States	Unknown	1 (0)	0	0
13632	United States	Unknown	1 (0)	0	0
13638	United States	Unknown	1 (0)	0	0

At least 22.7 grams of fentanyl were shipped. 207 reviews were of fentanyl patches and the other two listings were 10 grams of acetyl-fentanyl for \$446 and 10 grams of fentanyl powder for \$784. The average cost of a fentanyl product under 1 gram was \$19,888 per gram while fentanyl products over 1 gram cost an average of \$122 per gram. These price differences were because of the type of product sold. Fentanyl patches were significantly more expensive than powder or acetyl-fentanyl. They may have been preferred because they are generally seen as safer. The dosage on each patch is clearly written so there is a smaller chance that the user accidentally overdoses. Patches may also be popular because they are more convenient to use and have a longer effect period (The Recovery Village, 2020) than powdered fentanyl. The potential for addiction remains the same, however, fentanyl patches are less dangerous (The Recovery Village, 2020).

Buyers may have considered patches easier to use and were more interested in buying patches or considered fentanyl patches more trustworthy than other forms of fentanyl, and therefore there were more sales of patches. Cryptomarkets may have considered fentanyl patches a safer method of fentanyl use, as well. It appears that there is an informal allowance for certain vendors to sell fentanyl on ToRRReZ and WHM. Specifically, vendor 11735 was able to sell fentanyl on both cryptomarkets in large numbers that should be easy for the cryptomarket administrators to notice. It is likely that administrators were aware of the vendor and had allowed them to continue selling fentanyl because they either believe that there is less risk associated with fentanyl patches than fentanyl in other forms, or that the vendor was trustworthy.

No fentanyl vendors had any digital listings. This may imply that drug vendors that ship high-risk products were not as well versed in other areas because they want to focus on their drug products. Only one vendor, 13632, had both firearm listings and a fentanyl listing. The vendor had no reviews on any cryptomarket, indicating that they may have overreached, and buyers were hesitant to buy from them because they did not specialize in the riskier products and may not know as many safety measures as those who did specialize.

### **5.4.3. Major Vendors (Top 20 Drug Vendors)**

The top 20 drug vendors, included in Table 5.4, accounted for 16.0% of all drug reviews (76,431), 6.0% (1.3 tons) of drug products shipped and 13.8% (\$13.2 million) of the total drug cost. The average cost of a drug product by one of the top 20 vendors was \$173. The average amount per listing, for the products where an amount could be found, was 20.9 grams. 12,510 reviews did not have information on the quantity of drugs shipped. If it is assumed that the average amount shipped for the products that had an amount and those that did not were the same, then the top 20 drug vendors would have been responsible for 1.6 tons of drug products shipped globally. The vendors had averaged a first known join date of March 2020. All other drug vendors averaged a first known join date of October 2020. The major vendors were typically older than the average drug vendor.

Nineteen out of 20 vendors only sold drug products. Vendor 10080 was the only vendor to sell listings in multiple categories, they sold digital goods and parcel lockers in

addition to their drug products. Major drug vendors tend to focus their efforts on selling drug products rather than branch into different categories such as luxury or forged items. The specialization allowed them to become more experienced in shipping drug products and provide greater value for the price by offering higher quality services and products. They can increase their knowledge of shipping procedures and decrease the risk of the package being seized if they are aware of regulations and what shipping companies are or are not allowed to search. If there are changes, they can adjust their operational security accordingly. Increasing the number of categories unrelated to drug products could hinder the vendor's ability to keep up to date with the most recent shipping regulations, procedures, and best practices.

**Table 5.4 Top 20 Drug Vendors by Most Reviews**

Vendor	Location	Ships Worldwide?	First Join Date	Drug Reviews	On Number of Markets	Vendor's Main Products
11488	Germany	Yes	Jan 2020	7,445	5	Steroids
10522	United States	No	Nov 2019	5,456	4	Vape and Cannabis
10317	Germany	No	Jul 2020	5,103	4	Cannabis
11513	Germany	Yes	Feb 2020	4,544	4	Large Variety
10166	United Kingdom	Yes	Oct 2020	4,397	4	Prescription and Benzos
10969	United Kingdom	Yes	Dec 2019	4,345	4	Cocaine and Meth
10242	United Kingdom	No	Nov 2019	4,134	5	Cannabis and Cocaine
12531		No	Sep 2020	3,755	1	Cannabis
10034	United States	No	Feb 2021	3,496	2	Cannabis
11500	United Kingdom	Yes	Jan 2020	3,420	4	Cocaine and Meth
10036	United States	No	Feb 2020	3,354	4	Prescription and Benzos
10216	United States	No	Jan 2020	3,334	4	Alprazolam and Diazepam
10080*	Australia	Yes	Dec 2019	3,254	4	Variety of Benzos
12613		No	Sep 2020	3,034	1	Alprazolam and Diazepam
11307	United Kingdom	Yes	Jan 2020	2,968	4	Amphetamine
10006	United States	No	Aug 2019	2,885	3	LSD
10648	United States	No	Jan 2020	2,834	3	Amphetamine, Meth, and a large variety
11146	United Kingdom	Yes	Sep 2019	2,702	4	Amphetamine and MDMA
11485	Europe	Yes		2,657	1	Heroin and Cocaine
12296	Germany	Yes	Nov 2020	2,551	4	Cocaine and Cannabis

\*Vendor also sold digital goods and parcel lockers

Six vendors shipped from the United Kingdom, five from the US, four from Germany, one from Australia, and one from Europe. Two vendors did not state where they ship products from. All 18 vendors with a location consistently listed the same country they could ship from across cryptomarkets and listings. Only half of all major vendors offered to ship products worldwide. These vendors often had a large variety of products for sale, with only a few sales each. Most of their sales came from one or two primary products that differed from other major vendors in the same country. Major drug vendors did not struggle to compete against each other by only selling the same type of products. The major vendors may specialize in those few types of products or are known as more reliable for those types of products.

**Table 5.5 Cryptomarket Membership for Major Vendors**

Vendor	Dark0de	ToRReZ	WHM	World	Versus	Yakuza	Babylon	Total
11488	1	1		1	1	1		5
10522	1	1	1		1			4
10317	1		1	1	1			4
11513	1	1		1	1			4
10166	1	1	1	1				4
10969	1	1	1	1				4
10242	1	1	1	1	1			5
12531		1						1
10034	1			1				2
11500		1	1	1	1			4
10036	1	1	1	1				4
10216	1	1		1	1			4
10080	2	1	1	1				5
12613		1						1
11307	1	1	1	1				4
10006	1	2	2					5
10648	1	1	1					3
11146	1		1		1		1	4
11485				1				1
12296	2	1	1		1			5

Seventeen out of the top 20 vendors sold in multiple cryptomarkets, thirteen of whom sold in four or more cryptomarkets. Half of the major vendors sold products in at least Dark0de, ToRReZ and WHM, as shown in Table 5.5. There were three vendors who had multiple accounts on the same cryptomarket. Vendor 10080 had one main account used for business on Dark0de which was used to facilitate all their sales, and a

backup account that held no sales. Vendor 10006 had two accounts on ToRReZ, a primary business account that sold products and a backup account. On WHM, they had sales in both accounts, however, the accounts were created at different times. The first WHM account, which had more sales, was created in August 2019 and the second account was created in December 2019. Vendor 12296 had two accounts on Dark0de, one created in January 2021 and the second in May 2021. Neither account had any sales. The vendors may have duplicate accounts because a cryptomarket exit scammed and Dark0de, ToRReZ and WHM offered free vendor accounts for the vendors previously on those cryptomarkets. There were no major drug vendors on WTN.

Major drug vendors had, on average, nearly twice the number of accounts in different cryptomarkets than the average drug vendor. Greater exposure and ease of access by as many buyers as possible may have increased the number of sales major vendors had. Most cryptomarkets allow vendors to avoid the vendor bond if they have established a reputation as a reliable vendor on another cryptomarket. It would not cost the major vendors significantly more effort to increase the number of cryptomarkets they do business on.

## **5.5. Discussion**

Research question 2 argued that the same set of vendors move between different cryptomarkets to sell products and services. There is partial support found for research question 2. Vendors often migrate to different cryptomarkets when a large cryptomarket shuts down, as shown by the uptick in the number of second or third join dates in the same month or the month after a cryptomarket shuts down in Figure 5.1. The majority of vendors were only found on one cryptomarket at a time, however, when one cryptomarket is shut down, vendors were able to quickly migrate to other markets. Often, vendors migrate to the second largest cryptomarket because of how reliable and well known it is. Vendors do not tend to migrate to smaller cryptomarkets and prefer larger ones with an established reputation. During a cryptomarket shutdown, there is often an uptick in the number of second and third vendor accounts. Some vendors may decide to register on multiple cryptomarkets to reduce potential future disruptions to their business when a cryptomarket shutdown to remain accessible to their buyers.

Users may consider three major questions when choosing a cryptomarket:

- 1) How trustworthy is the cryptomarket? If a cryptomarket has only been active for a short period of time, vendors and buyers are unsure of how disputes are handled and if the administrator is able to deal with problems if they arise. Older cryptomarkets with a large number of sales can be seen as more reliable than newer cryptomarkets. Older cryptomarkets have been tried and tested by other users and shown to be a trustworthy platform to conduct business if it still houses a large population of vendors and buyers. The cryptomarket administrator, over time, has shown themselves capable of handling their cryptomarket and issues that appear.
- 2) Are there sufficient buyers on the cryptomarket who would buy products? If there is a larger number of buyers who use the cryptomarket, there is greater demand, increasing the chance that a vendor's products are purchased. The more buyers on a cryptomarket, the more attractive the cryptomarket is for vendors. In turn, buyers may prefer cryptomarkets that have a large selection of vendors and products.
- 3) Are there more beneficial options? Some cryptomarkets have additional security features, such as multi-signature wallets that require two parties (cryptomarket and vendor, cryptomarket and buyer, vendor and buyer) to transfer funds (Coinguides, 2021) and reduce the likelihood of the cryptomarket exit scamming because they are not able to profit from exit scamming. Other markets allow trustworthy vendors and those from newly defunct cryptomarkets to join without paying the vendor bond.

A large percentage of vendors may seem to be first time vendors because they changed their username between cryptomarkets or were part of a cryptomarket not included in the dataset. Only eight cryptomarkets were collected out of a potential 33 markets at the time of data collection, not including the previous major cryptomarkets that spurred large numbers of user migration. The migration habits of some vendors will be missing and underrepresented in the data.

Established vendors on a long lived cryptomarket that shut down had a more staggered timeframe for account creation compared to newer vendors who recently migrated. Vendors out of date on which cryptomarkets are most profitable likely require a

greater amount of time to research and catch up on the events in the cryptomarket ecosystem and determine the most optimal market to sell on. Newer vendors were less likely to require as much time because their research is not out of date yet. Some of the cryptomarkets they previously researched would still be available and they already know if the cryptomarket is the next most profitable or not.

Buyers who purchase products from an established vendor on a single cryptomarket may reach out to other vendors for their next purchase if their preferred vendor is still searching for a new cryptomarket to sell products on (Décary-Héту & Quessy-Dore, 2017). If they prefer to wait for their usual vendor, they may have to wait a longer period of time until the vendor is able to be found again by creating a new account on another cryptomarket. Vendors on multiple cryptomarkets are more resilient to cryptomarket disruptions (Bradley, 2019). They are able to retain their old buyers and sell products to new buyers when other vendors are inaccessible. Major drug vendors had twice the number of accounts compared to the average drug vendor. The increased exposure and ability to continue business when major cryptomarkets are disrupted likely increased the number of purchases they have and buyers they sell to.

Most successful drug vendors focused exclusively on drug products and did not tend to sell products in other categories. Fentanyl vendors did not have any digital listings and tended to only sell within the drug category. Vendors who sold high-risk products were not as well versed in other areas because they were focused on how to minimize risk and successfully ship their products to the buyer. There was only one fentanyl vendor who also had firearm listings; however, they had no reviews on any cryptomarket implying they overreached in attempt to be able to sell high-risk products in multiple categories. Vendors who ship products from multiple locations tend to have, on average, 349.5 more reviews than those who only ship from one location or did not list a location. The less time a drug vendor has been on cryptomarkets, the less likely they were to offer to ship worldwide, indicating that vendors learn more about the procedures of worldwide shipping and may acquire the skill while they are vendors. Not all vendors decide to ship worldwide, half of the major vendors were content to limit where they ship products and reduce risk rather than increase the number of potential buyers.

Research question 3 argued that there are factors that will influence a drug vendor's ability to ship drug products internationally, such as more experience on

cryptomarkets (RQ 3A), a greater number of drug products they sold (RQ 3B), a greater variety in the types of products they can sell (RQ 3C), and the number of cryptomarkets they were found on (RQ 3D). Support was found for research question 3. Four Mann Whitney U tests were conducted to examine if the following factors influenced a drug vendor's ability or willingness to ship drug products internationally; the effects of the variety of products a vendor sold, the earliest date when the vendor registered as a vendor, number of drug reviews, and number of locations they stated they could ship from, to the drug vendor's ability to ship products worldwide.

There was a difference in the amount of time vendors were on cryptomarkets between vendors who sold internationally and those who did not. Research question 3A is supported. The median for vendors who offered international shipping were on the cryptomarkets for a longer period of time than vendors who did not. Vendors may develop the ability and confidence to successfully ship drug products internationally. They learn professionalism and the skill needed to ship drug products with experience, increasing the odds that they can successfully reach a larger audience. Vendors are able to learn and take pride in their work (Martin et al., 2020), which will likely increase the chances that they continue offending (Clarke & Cornish, 1985). Those with more experience may perceive the risk of their packages being seized as lower than vendors with less experience, therefore, they are more willing to ship products internationally. If vendors are satisfied with their client base in their local region and do not desire to increase operations and sales by appealing to a greater number of potential buyers, such as in the case of major vendors, they may decide not to ship internationally.

The number of drug products sold was significantly different between vendors who shipped internationally and those who did not. Research question 3B is supported. Vendors who offered international shipping likely had a larger pool of potential buyers than those who did not, thus, they may have had more sales than vendors who did not offer international shipping. The median number of drug reviews for vendors who shipped internationally was greater than those who did not ship internationally.

The variety of products a vendor can sell differs significantly between vendors who offer international shipping and those who do not. Research question 3C is supported. Vendors able to successfully ship a variety of products can become a one-stop shop for buyers with diverse needs or can attract a greater number of buyers who

desire various products. Buyers who have already purchased a product from a diverse vendor could be more willing to purchase from them again if they had a good experience. There would be less hesitation and doubt that the other party is a scammer. While generalists may be able to gain a greater pool of buyers, they may not be able to specialize as well in each different type of product as a specialist. Therefore, the package quality of specialists may surpass those of generalists. Vendors who specialize in sensitive and high-risk products, such as fentanyl or firearms, may be more likely to gain buyers than those who sell both fentanyl and firearms.

Shipping domestically may decrease the odds of a package being seized if a vendor is in the same country as the buyer, because it is often less risky to ship a product domestically. Major drug vendors typically only shipped drug products from one location. It is less likely that the most successful drug vendors are made up of groups of people working under one vendor account. For most in-person offenders, generalists may have more sales (Clarke & Cornish, 1985) than specialists, yet be less successful if they are alone. Small groups of cryptomarket vendors are more able to sell a variety of products while providing adequate value for the price.

The number of cryptomarkets a vendor is available on differs significantly between vendors who ship internationally and those who do not. Research question 3D is supported. International vendors had a median of two cryptomarkets they are available on compared to the median of one cryptomarket for vendors who do not ship internationally. Vendors who ship internationally may desire to increase attention from buyers and increase their number of sales. These vendors appear to be more willing to take on risks than specialized vendors.

Only two vendors who sold blueprints for 3D printed firearms did not specialize in digital goods. Eight blueprint vendors primarily sold digital goods and likely saw the blueprints as an interesting addition to their selection of digital products rather than their main product as a weapon blueprints dealer. Vendors who primarily focused on physical firearm products were more successful than those who split their attention. Physical firearms focused vendors provided greater value by minimizing their digital footprint when listing and selling firearm related products by using custom listings.

Custom listings require more steps and effort than other listings. These listings are often removed after the transaction is complete, limiting the amount of time they can be seen, and making them more difficult to find. On some cryptomarkets, once the listing is removed, all information related to the listing is also removed, including reviews and the number of sales for each vendor. This provides greater protection and reduces the digital footprint left. It is likely that there were more firearm products purchased than what was observed. All sold physical firearms were custom listings by a vendor who specialized in firearm products and was likely seen as having a greater value for the price than vendors who tried to sell multiple different types of products (Xu et al., 2017). Buyers may have been concerned that the generalist vendor would not provide an adequate value for the price.

To better account for purchases of firearm products, it would be best to examine cryptomarkets for custom listings over time. This reduces the likelihood of firearm products being missed because custom listings were removed once the transaction was completed. It may still be difficult to identify the contents of a custom listing because some custom listings will only state that it was the product discussed in private messages. Some custom listings could be of drug products, however, if a firearm vendor who sells primary firearms has many unidentified custom listings, it is likely that a number of the custom listings contain firearm products.

## Chapter 6. Products

Vendors could sell a large variety of products, partly because cryptomarkets banned very few items from their markets. Not all cryptomarkets banned the same products, so it was possible to access commonly banned products, such as firearms or fentanyl, from cryptomarkets that did not ban these products, such as Yakuza. Buyers could access an assortment of products on the cryptomarket ecosystem including but not limited to; drugs, banking information, forged identification, signal jammers, counterfeit currency, and firearms. All of these products had shown signs of being purchased.

There were 841,004 reviews found from the eight cryptomarkets in the dataset. To estimate the number of total sales, two factors were considered. 1) The older the data was, the more likely that listings would have been removed, consequently the older the data was from the date of data collection, the less accurate the estimation would be due to potentially missing data. For example, listings posted in January 2021 were more likely to have been removed from the cryptomarket by the time of data collection than listings posted in June 2021. June 2021 was used as a baseline and the percentage of listings found in June 2021 was applied across all cryptomarkets to reduce the inaccuracy of older listings. 2) Only 55% of sales resulted in a review and only unique reviews were used to estimate the total number of reviews. It is estimated that there were 2.1 million annual purchases across eight cryptomarkets.

Digital products still do not account for the majority of the products sold on the cryptomarket ecosystem, however, the percentage of digital products on the younger cryptomarkets has risen. Digital products are products that can be sent over the internet or by other digital means that do not involve physically shipping an item. The digital listings on Silk Road in 2011 and 2012 contributed to 1.1% of the total listings (Christin, 2012). The percentage of digital listings increased to 40% on Dream market in 2018 and 2019 (Zhou et al., 2020), dropped slightly to 37.9% on World market in 2021, and increased to 60.3% on WTN in 2022. Commonly sold digital products included cards and CCV, guides and tutorials, software, and personal information such as date of birth, social security numbers, and names. Some cryptomarkets had a card shop where individual credit cards would be sold. There were no reviews found in that section of the

cryptomarket. This can imply that the total number of digital listings has been underreported in the data and the actual number of purchases and digital listings should be higher than what is currently seen.

Over time, the percentage of digital goods available has been increasing. Digital products have only contributed to 14.7% of purchases. Drug products still dominated the cryptomarket sales with 84.9% of the purchases. Nearly all cryptomarkets had a greater number of drug products sold than digital listings. Drugs have a physical form and must be shipped to the buyer, which means there is a greater opportunity to intercept it during the shipping process. There will be a greater focus on the drug products trafficked using cryptomarkets because it was the most often sold product and had a physical location.

## **6.1. Drug Products**

Across eight cryptomarkets, there were 474,778 drug product reviews for 2,404 unique drug vendors, which cost a total of \$95.1 million. At least 4.5 tons were shipped based off the 410,396 listings that had a drug amount listed. Each product costed an average of \$200 and shipped an average of 10.9 grams. Accounting for the sales to review ratio, it is estimated that there were 863,233 drug sales costing a total of \$172.7 million for 8.1 tons of drugs being trafficked. These estimates do not account for when cryptomarkets shut down, or listings and vendors leave the cryptomarket. Estimating the sales per month better controls for listings and cryptomarkets leaving the ecosystem.

Listings have a greater chance of being removed after five months and June 2021 had the greatest number of reviews across WHM, ToRRReZ, Babylon and World market. To more accurately estimate the total amount of money obtained by these eight cryptomarkets and their vendors from drug sales, the estimate will be based on one month and account for sales where the buyer may not have left a review. First, the average price per product sold, for products that had a price above zero, was multiplied by the number of reviews that were expected to appear in June 2021. Then, the number was divided by 0.55 to account for the number of expected sales that did not leave a review. Finally, the number was multiplied by 12 for an annual estimate. It was estimated that there were 12.9 tons of drugs trafficked, costing \$238.6 million annually. May (2017) estimated that the global drug trafficking market for cannabis, opiates and amphetamines was worth between \$538.6 billion to \$824.4 billion CAD in 2017. The

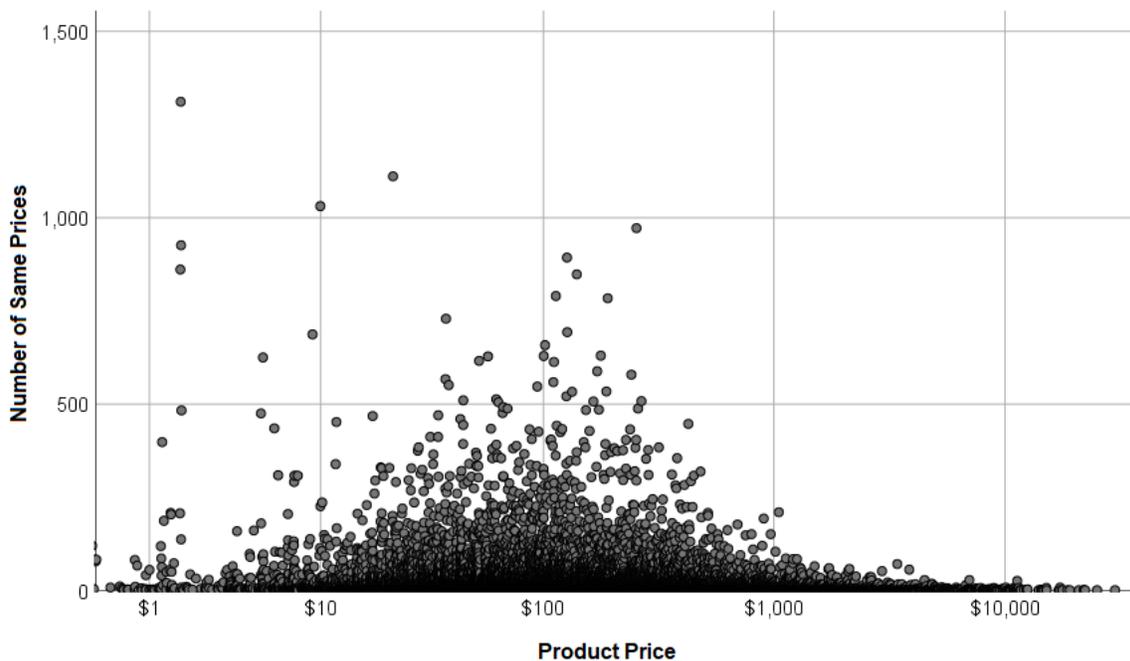
sales of all types of drugs across eight cryptomarkets were found to be worth between 0.03-0.04% of the global drug trafficking. Cryptomarket drug trafficking only contributes to a fraction of the global drug trade.

There were four factors that likely resulted in an underestimation of the price of drug products on cryptomarkets. 1) The marketplaces collected were all English speaking cryptomarkets. Other large cryptomarkets in different languages were not collected. 2) There are often additional shipping costs that buyers pay separately from the cost of the drug, while in-person drug dealing would have that price built in already. 3) There are vendors who list inaccurate prices on the product listing while stating how much each gram costs in the description of the product. Sometimes, the price would be listed at \$0.01, and the actual cost of the product would be within the description. The product description and name were not examined for the price. 4) There were listings that had been removed from the cryptomarket and the review was missing information, therefore, the product was not included in the estimate. These four factors combined should not have a significant difference in the amount of drug trafficking that cryptomarkets facilitate compared to the total global drug trafficking.

### **6.1.1. Personal Use or Wholesale**

Some articles would determine the standard for wholesale by the quantity of one drug product being sold (Caulkins, 1994; Lamy et al., 2020). Others use a price to estimate wholesale (Aldridge & Décary-Hétu, 2016), when there were multiple different drug types. Since there is a magnitude of different drug types, a price will be used instead of a quantity. \$1,000 USD was previously set as a conservative estimate of wholesale (Aldridge & Décary-Hétu, 2016). To determine if \$1,271 CAD is a reasonable standard for wholesale, the price of drug products and the number of times they were purchased was considered. Figure 6.1 contains a dot plot of the drug prices and number of times a product costing the same price was sold. Around the \$1,000 mark, there are fewer sales. Following a slight bump around \$1,271, the number of dots and frequency of sales continues to drop. \$1,271 would still be a reasonable threshold of defining wholesale, in addition, it allows for comparisons between this study and Aldridge and Décary-Hétu's study from 2016.

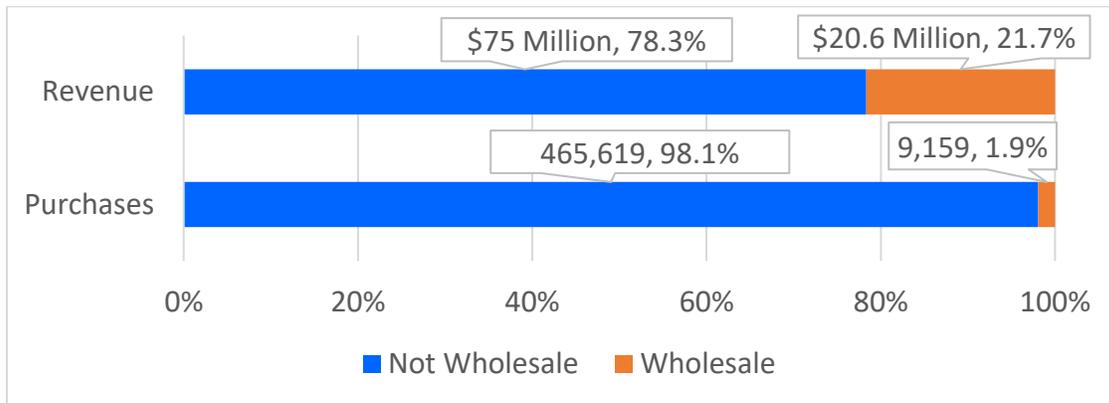
Another way of defining wholesale would be setting the standard much higher, closer to \$10,000 because the number of sales starts to thin out more around that price. This would imply only the most expensive sales are wholesale, potentially missing some wholesale activity where the buyer is purchasing less, but more frequently. There were 125 listings that costed \$10,000 or more, the majority were methamphetamine (35.2%), ketamine (24.0%), and cocaine (20.0%). There were at least 79.7 kilograms sold and costed slightly over \$1.7 million. Six products (4.8%) were custom listings. It is difficult to compare this to other cryptomarket studies; thus, the \$1,000 USD standard will be used for a better comparison.



**Figure 6.1 Dot Plot of Drug Prices**

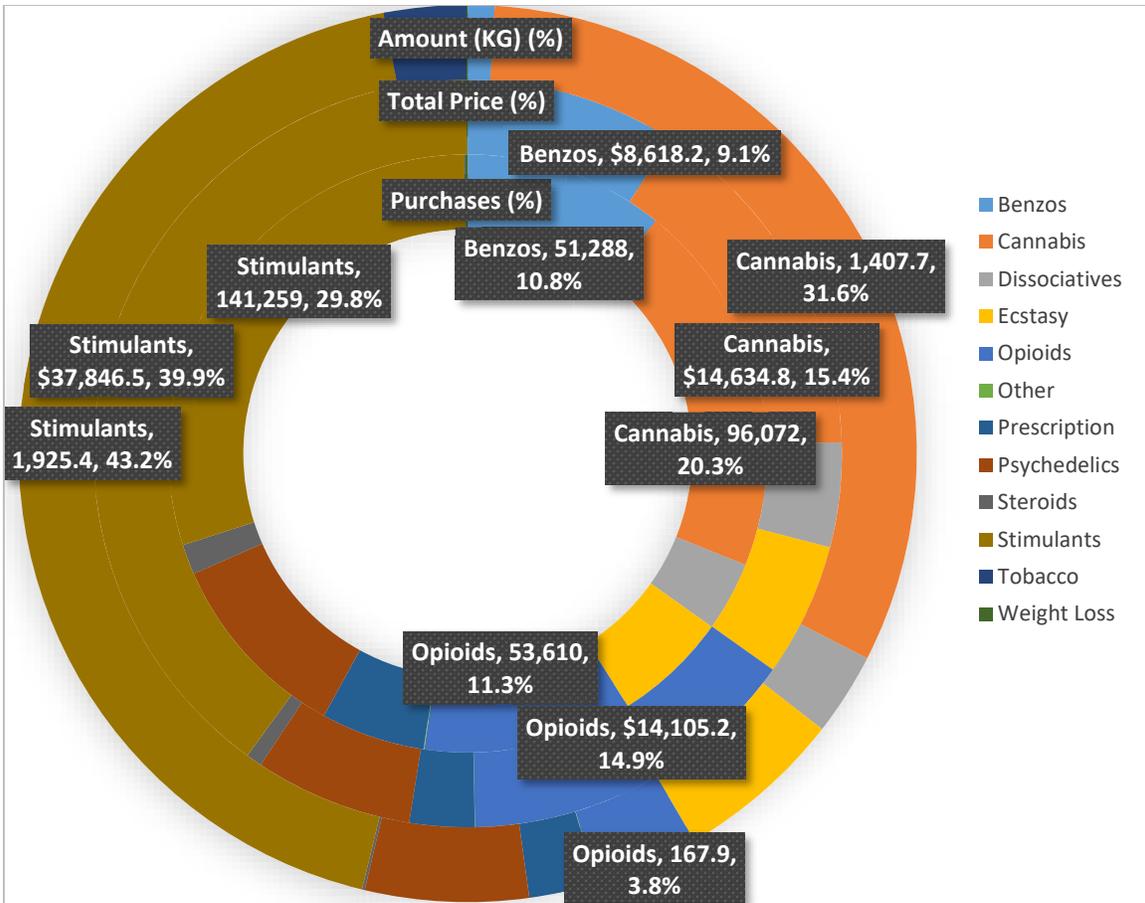
An average of 54.5 grams of drug products were trafficked for each product sold, however, products with large quantities only contribute to a small number of the total purchases, skewing the average amount of drugs shipped. Figure 6.2 contains the revenue and number of all drug purchases divided by wholesale and not wholesale. Wholesale listings were those costing \$1,271 or more. Only 1.9% of all drug products were wholesale, however, that small percentage of purchases accounted for 21.7% of the entire drug revenue of eight cryptomarkets. 75% of all drug purchases contained 5 grams or less. The top 5% of drug products with the greatest amounts were all 28.4

grams or greater. The vast majority of drug products contained significantly fewer grams and were shipped in small amounts and packages.



**Figure 6.2 Wholesale Revenue and Purchases**

Figure 6.3 shows that stimulants were the most purchased drug product (29.8% of all purchased drug products), had the greatest percentage of revenue by drug products at 29.8%, and contributed to 43.2% (1.9 tons) of the amount of all drug products sold. The large packages were primarily speed paste shipped at a cheap price for a large amount. There were also large packages of methamphetamine sold at an expensive price. The remainder were small and expensive stimulant products, shipped many times over. The largest orders of stimulants were dominated by amphetamine paste, followed by methamphetamine. Cannabis was the next most often sold drug type, which accounted for 20.3% of all purchases and 31.6% of the total quantity of drug products shipped. Cannabis was often shipped in large amounts for a low price compared to other types of drugs, such as opioids. Opioids were shipped in small amounts for a high price, totalling 3.8% of the number of drugs shipped, accounting for 11.3% of all reviews and 14.9% (\$14.9 million) of the total drug revenue. Benzodiazepines accounted for 1.0% of the total amount of drugs shipped and was the fourth most often purchased product with 10.8% of purchases being of benzodiazepines.



**Figure 6.3 All Drug Category Amounts(KG), Price(Millions), and Purchases**

### 6.1.2. Location and Drug Index

The number of drug products shipped from each country and if the product had the option of worldwide shipping was examined in Appendix B to identify if products from different countries are more likely to offer worldwide shipping or not. This accounts for vendors with shipping origins in multiple different countries. There were some listings that stated they shipped from “worldwide”, however, did not offer worldwide shipping. It is possible that vendors only stated that they shipped from worldwide in attempt to obfuscate where the vendor was based. The vendor may also ship from multiple locations and decided to simply state they shipped products from worldwide rather than specifying the locations they can ship from.

There are some countries where the products are primarily shipped within the country, such as Australia, Poland, and the United States. There are other locations

where products are more commonly able to be shipped worldwide, including India, the Netherlands, and vendors who stated that they ship from the European Union or worldwide. There are policies from individual countries that can discourage cryptomarket drug vendors from attempting to ship their products internationally. Poland has a legal dispute with the EU because Poland determined that EU law does not supersede the country’s law (Nino, 2021), which may affect trade relations and subsequently affect where vendors are willing to ship to.

**Table 6.1 Drug Index**

Drug	Price per Gram (All)	Price per Gram (Canada)	Street Price per Gram (Canada)	N
2C-B	\$21.52			4,141
Alprazolam	\$329.38	\$242.11		26,417
Amphetamine	\$249.16	\$1,446.69		15,612
Buds and Flowers	\$7.39		\$10-20.00	47,935
Cocaine	\$89.86	\$55.90	\$100.00	59,290
Codeine	\$3.51	\$584.30*		1,988
Crack	\$135.00			3,332
Etizolam	\$107.72	\$562.50*		1,661
Fentanyl	\$134.84			811
Heroin	\$73.72	\$127.90	\$140-600.00	26,416
Ketamine	\$29.54	\$54.50		12,918
LSD	\$3,416.95	\$24,693.10*		18,815
Magic Mushrooms	\$6.07	\$3.50		10,270
MDMA	\$18.13	\$19.20		25,310
Methamphetamine	\$26.37	\$21.50	\$30-150.00	23,905
Morphine	\$356.83			854
Oxycodone	\$389.17	\$571.70		6,689
Zopiclone	\$168.73			2,529

Table 6.1 is a shortened version of the drug index in Appendix A, containing the most common drug products, drug products of interest, and those with a Canadian counterpart to compare with. The “Price per Gram (Canada)” column only included products that ship exclusively to Canada. The majority of the Canada specific products had less than 20 reviews, which may skew the price of each listing. The only location that would ship products solely to Canada was Canada. The only vendors who ship exclusively to Canada were from Canada. The “Street Price per Gram (Canada)” was created using data from the United Nations Office on Drugs and Crime (2021b).

Products that shipped solely to Canada tended to be more expensive per gram, including amphetamine, codeine, etizolam, heroin, ketamine, LSD and oxycodone. Amphetamine in Canada may have had a greater percentage of prescription amphetamine pills while other amphetamines being shipped included a greater percentage of mixed or homemade products, lowering the cost of amphetamines per gram. Other products may be more difficult to obtain and sell in Canada than in other parts of the world, increasing the cost of shipping the package to Canada. Other products, such as MDMA, were sold for similar prices worldwide and to Canada.

Methamphetamine and cocaine in Canada were significantly cheaper than worldwide. Methamphetamine and cocaine were the main stimulant products being shipped in WTN, the Canadian specific cryptomarket, indicating that meth and cocaine are Canada's specialty. Vendors in Canada with access to it and are willing to sell internationally may find a greater number of buyers who wish to purchase the drug. Street prices for cocaine in Canada cost nearly twice the price of their cryptomarket counterparts. Cocaine shipped to Canada on cryptomarkets cost \$56 per gram while the street prices were \$100 per gram (United Nations Office on Drugs and Crime, 2021b). When a range was given, the price of the drug on cryptomarkets were below the lower range. Methamphetamine in Canada cost \$22 per gram and the range for street prices was from \$30-150 (United Nations Office on Drugs and Crime, 2021b). The international price was also below the Canadian street price.

The price per gram of drug products on cryptomarkets, in Canada or otherwise, was uniformly lower across drug products compared to the street price in Canada. Vendors in Canada may have easier and cheaper access to the product and can sell for less money while still making a profit. The lower price in Canada may force other Canadian vendors to lower their prices if they wish to remain competitive. Part of the reason the price on cryptomarkets was significantly lower than in-person was likely due to the decreased risk of being caught or sent to prison and the little to no risk of physical violence, which makes a combined total of 57% of the revenue of in-person sales of cocaine and heroin (Caulkins & Reuter, 1998). The vendor must still acquire the products; thus, it is unlikely that the total cost would decrease by 57% because it is unknown if the drug had to be smuggled to the vendor or if they manufactured the product themselves.

The products most often shipped from Canada were methamphetamine, cocaine, heroin, and LSD. Methamphetamine was the most often sold product from Canada to worldwide. It was sold 371 times and was worth \$78,915. Cocaine was the second most often sold produce with 263 products worth \$51,050. LSD was significantly more expensive when shipping to Canada. The vendors who sold LSD within Canada formatted their products in a way that was difficult for the programs used to identify the amount of each drug per listing to output the correct information.

### **6.1.3. Price and Quantity of Type of Drug for Worldwide Shipping**

Not all drug products ship worldwide. The product price included in this analysis was the cost of the product listing. The type of drug may limit the vendor's ability to ship the quantity worldwide for the price. The price of shipping was not always available or visible, thus, the price does not include the price of shipping, only the price of the base product being shipped to the location. The product price likely includes the risk of shipping internationally, however, it likely does not include the price of delivery by the shipping service. More expensive products often contain a greater quantity, and if the product is seized, can result in a deficit for the vendor if they offer partial refunds or reships. A greater quantity being shipped can make the product bulkier and increase the chances of it being caught. The variables of quantity and price were commonly found across the majority of drug products.

Each drug product listing with at least one review was included in the Mann Whitney U tests to determine if there are factors that influence the likelihood that a product is able to ship worldwide. The shipping destination was binary, either the product could be shipped worldwide, or it could not. The variables of product price and quantity were not normally distributed; thus, a non-parametric test was used. To evaluate the differences between the price and quantity of drug products that would be shipped internationally and those that would not be, Mann-Whitney U tests were conducted on every drug type which had over 10,000 unique reviews. There were twelve drug types which had over 10,000 reviews, cocaine, marijuana buds and flowers, heroin, alprazolam, MDMA, speed, methamphetamine, LSD, amphetamine, ketamine, diazepam and magic mushrooms.

The Mann-Whitney U test in Table 6.2 reveals that there were significant differences between all drug types and the price at the  $p < 0.001$ . The prices all had at least small effect sizes for social sciences at  $r = 0.1$  or greater (Cohen, 1988). Heroin, amphetamine and alprazolam all had medium effect sizes at  $r = 0.3$  or greater (Cohen, 1988). Examining a wide variety of popular drug types, Table 6.2 shows that price is a significant variable for if a product can be shipped internationally or not. Research question 4A is supported.

**Table 6.2 Differences Between the Prices of International and Non-International Drug Shipments per Drug Type**

Drug	Effect Size	Not International Median	International Median	U	z	N
Cocaine	-0.27	217.53	109.545	93,892,439.5	-50.49	36,208
Buds and Flowers	-0.14	111.11	68.46	37,836,512	-26.67	36,443
Heroin	-0.47	161.77	51.14	14,258,323.5	-62.91	18,030
Alprazolam	-0.35	153.15	66.2686	25,184,247	-49.97	19,899
MDMA	-0.27	106.72	51.805	24,233,785.5	-36.37	17,810
Speed	-0.11	73.16	51.54	21,428,598	-13.99	14,839
Methamphetamine	-0.19	180.43	70.55	8,463,731	-24.96	16,581
LSD	-0.20	88.53	46.97	25,087,839.5	-25.75	16,184
Amphetamine	-0.34	217.7	63.59	3,951,818	-36.26	11,502
Ketamine	-0.16	111.95	91.24	11,322,803	-16.64	10,735
Diazepam	-0.13	51.9	41.56	10,162,786	-13.32	9,900
Magic Mushrooms	-0.19	99.72	62.65	2,563,384.5	-16.29	7,462

The Mann-Whitney U test in Table 6.3 reveals that there were significant differences between all drug types and the quantity, with cocaine, marijuana buds and flowers, heroin, alprazolam, MDMA, speed, methamphetamine, LSD, amphetamine, and ketamine significant at the  $p < 0.001$ . A few drug types did not meet the threshold of a small effect size, including cocaine ( $r = -0.09$ ), alprazolam ( $r = -0.08$ ), amphetamine ( $r = -0.08$ ), magic mushrooms ( $r = -0.04$ ), and diazepam ( $r = -0.02$ ). Marijuana buds and flowers, heroin, MDMA, speed, methamphetamine, LSD, and ketamine all had small effect sizes. The quantity of drug types and how much was shipped appears to have a smaller overall effect on if a product is shipped internationally or not, compared to the price. Research question 4B is supported.

**Table 6.3 Differences Between the Quantity of International and Non-International Drug Shipments per Drug Type**

Drug	Effect Size	Not International Median (g)	International Median (g)	U	z	N
Cocaine	-0.09	2	1	109,589,259.5	-16.93	34,101
Buds and Flowers	-0.12	7	3.5	27,089,927	-20.79	30,645
Heroin	-0.24	1	1	19,321,440.5	-30.91	16,257
Alprazolam	-0.08	0.05	0.06	35,112,246.5	-10.40	18,257
MDMA	-0.10	2	0.4	25,273,911.5	-13.01	16,092
Speed	-0.11	5	10	16,503,453.5	-12.13	13,277
Methamphetamine	-0.14	2	1	8,319,329	-16.26	14,354
LSD	-0.14	0.001	0.00026	15,675,731.5	-15.52	12,233
Amphetamine	-0.08	0.3	0.25	6,356,403	-8.18	10,862
Ketamine	-0.13	1	2	8,425,574.5	-12.39	9,020
Diazepam**	-0.02	0.3	0.2	8,250,814	-2.01	8,237
Magic Mushrooms*	-0.04	7	11	-16.29	-3.41	6,713

\*Significant at 0.001

\*\* Significant at 0.04

## 6.2. Discussion

There were 841,004 purchases found across eight cryptomarkets. It is estimated that there were 2.1 million annual purchases across eight cryptomarkets and of those purchases, the percentage of digital products sold has been increasing. This may reflect the increase on cybercrime and the corresponding increase in user information or hacked databases available. The total number of digital product reviews to digital products has a smaller proportional percentage than that of the drug reviews to drug products. Buyers of digital products could be more cautious about leaving reviews than drug buyers because reviews are a digital footprint. There could also be less demand and interest in digital goods than drug products.

There was an estimated 12.9 tons of drugs trafficked on cryptomarkets annually, costing a total of \$238.6 million. The majority of drug products were shipped in small quantities and packages, with half of all drug products containing 1 gram or less and 75% of drug products with 5 grams or less. Stimulants were the most commonly purchased drug product followed by cannabis, opioids, and benzodiazepines. Benzodiazepines were found in 44% of overdoses in British Columbia and cannot be reversed by naloxone (British Columbia Coroners Service, 2022; Government of

Canada, 2021). Benzodiazepines were primarily shipped in packages containing small quantities for high prices. With a small package, these commonly sold products had the potential to contribute to overdoses that could not be stopped by naloxone. No cryptomarkets were observed to have rules restricting the sale of benzodiazepines similar to those that ban fentanyl sales. Cryptomarkets could be used as an alternative source to access these products.

The drugs found on cryptomarkets, worldwide and in Canada, were found to be uniformly cheaper than the street price in Canada (United Nations Office on Drugs and Crime, 2021b). Certain drug products such as methamphetamine and cocaine were often shipped from Canada to worldwide because it was, on average, cheaper than the price on cryptomarkets elsewhere. These two were the most often purchased products shipped from Canada to worldwide because the Canadian vendors could be more competitive and therefore, more attractive to buyers (Xu et al., 2017). Methamphetamine and cocaine were the most commonly sold products, matching what is often sold on the streets in Canada (Biggar, 2021), and showing that cryptomarkets reflect the supply within countries.

For products that ship only within Canada, there were significant differences in price per gram compared to the overall drug index. Amphetamine, codeine, etizolam, heroin, ketamine, and LSD shipped within Canada were more expensive than products being shipped elsewhere. Vendors have the option of selling products that they cheaply obtained to areas where the drug is more difficult or expensive to obtain, generating a greater profit than selling products in the local area in-person. Selling products on cryptomarkets is also physically safer for all parties and often more professional than offline dealing (Martin et al., 2020).

There is a greater incentive to purchase and sell on cryptomarkets rather than in-person. Buyers have already shown themselves to consider the price when making purchasing decisions (Décary-Héту & Quessy-Dore, 2017; Xu et al., 2017). It would be sensible for buyers to also consider making purchases from cryptomarkets to reduce the total cost needed to obtain their drug of choice. Increased demand from buyers would prompt a greater amount of revenue and profit to be gained by vendors and administrators on cryptomarkets, allowing cryptomarkets to grow larger. More products and services may move onto cryptomarkets because they provide a physically safer

alternative route to deliver products if in-person delivery becomes less desirable. These alternative routes to obtain products may exacerbate issues such as benzodiazepine related overdoses.

Research question 4 argued drug packages have characteristics that will affect if vendors decide to ship them internationally, such as the price of a product (RQ 4A) and quantity (RQ 4B). Smaller quantities imply a smaller package, and less expensive products mean there is less risk for the vendor if the package is seized. Mann Whitney U tests were conducted to examine if the product price and quantity differ in products that can ship internationally and those that could not. There was support found for research question 4. There were significant differences in price for products that could be shipped internationally and those that would not be. Research question 4A was supported. The medians of products that can be shipped internationally were smaller than those that did not offer international shipping. The more expensive the product, the greater risk the vendor must take (Caulkins & Reuter, 1998). For products that may have been considered high-risk, the vendor may have preferred to not increase the risk by offering international shipping.

There were significant differences in the quantity of products that could be shipped internationally and those that would not be. Research question 4B was supported. While all drug types had a significant difference between the quantity of products that could be shipped internationally and those that could not be, the effect size did not always meet the threshold for a small effect size and some products had a smaller median for products that could be shipped internationally than could not be, while others had smaller medians for products that could not be shipped internationally than could be shipped internationally.

Wholesale drug products could be at greater risk when shipped internationally. It may be more difficult to hide from the scrutiny of international searches and would be a greater loss for the vendor and buyer if an expensive package is seized compared to less expensive packages. Products containing small quantities were less likely to be shipped worldwide than medium and large quantities, likely because of the cost of shipping and the time required for delivery. International deliveries can take a longer time, so if the buyer only purchases a small quantity, they may run out and the next shipment may not arrive as quickly as the buyer would like. The fee for shipment and

delivery, if it does not vary for different quantities and is more expensive for worldwide shipment, may also discourage buyers from purchasing small quantities to be delivered internationally. Reasonably sized products that are not overly expensive are the products most often shipped internationally. Vendors pick and choose the options that bring them profit while keeping the risk to a tolerable level.

Research question 5 argues that the majority of drug transactions are for personal use rather than wholesale. There was support found for this. 98.1% of drug products sold were not considered wholesale products, over \$1,000 USD as defined by Aldridge and Décary-Hétu (2016). Wholesale drug sales still accounted for 18.5% (\$20.6 million) of the total income across eight cryptomarkets. The number of purchases and the amount of revenue they accounted for decreased significantly since 2013 (Aldridge & Décary-Hétu, 2016). This may be due to COVID-19 when individuals would rather stay inside than meet drug dealers on the streets where they are more visible due to the decrease in the number of people outside (United Nations Office on Drugs and Crime, 2021a). Ordering drug products and having it shipped directly to the buyer's house would be more convenient and less risky during a pandemic.

Regulations and procedures for shipping likely have an impact on the vendor's ability to traffic drug products. Products from Australia and the United States rarely ship worldwide. The products in other countries tend to be able to ship worldwide, such as Europe and the Netherlands. Australia likely has strict border control that prevents products from successfully being shipped worldwide (Broeseus et al., 2017a). Drug products in Australia were more expensive, the combination of a wealthy population and heightened security measures at the border lowered the likelihood of a successful shipment, which makes shipping internationally less profitable (Broeseus et al., 2017a). Factors that may reduce the likelihood of products shipping worldwide are:

- 1) Strict border control and effective methods that are capable of identifying and seizing packages that contain drug products.
- 2) High domestic demand from the buyers within a country and the ability to profit without increasing risk by shipping worldwide. If domestic demand provides sufficient profit for vendors, they are less likely to ship products worldwide.

- 3) Vendors believing that the potential profit gained from shipping the product internationally is not worth the risk.

There are likely policies that can discourage drug shipping using delivery systems and increase the risk vendors take when shipping their products. Individual vendors who consider profit and risk, can determine which products are the most suitable to ship worldwide according to their own analysis and perception of risk. To inhibit global drug distribution from cryptomarkets, identifying the characteristics of these packages that are often shipped internationally could increase the number seized. Some vendors may be deterred if drug packages are more commonly seized and the perception of risk to ship internationally increases, encouraging them to reconsider if it is still profitable to ship internationally.

## Chapter 7. Conclusion

Cryptomarkets are marketplaces on the dark web that facilitate the sale of goods and services between vendors and buyers (Christin, 2012; Martin, 2014; Bradley, 2019; Barratt, 2012). The majority of individual cryptomarkets only last a few months to a couple of years before they shut down or are seized by law enforcement (Branwen, 2018). Despite the limited time they are active, there are many new cryptomarkets constantly appearing and the vendors and buyers are able to swiftly migrate to other cryptomarkets to continue business (Branwen et al., 2015; Dark Web Link, 2021; Dark.link, 2022; Bradley, 2019; Buskirk et al., 2016; Décary-Héту & Giommoni, 2016). Cryptomarkets use postal delivery to send products and can be used as alternative methods to access products outside of more traditional trafficking or in-person methods. These marketplaces may have been neglected as a route for criminal activity and illicit trade, thereby missing a section of activity that potentially provides greater insight into issues related to items for sale on these markets.

Eight cryptomarkets were selected for data collection. Five cryptomarkets were selected because they were the largest cryptomarkets accessible during data collection, White House Market, Versus, ToRRReZ, Dark0de Reborn, and World market. Two cryptomarkets contained a greater percentage of fentanyl and firearm products, Yakuza and Babylon. Finally, WTN was the last cryptomarket collected, a Canada specific cryptomarket that appeared in July 2021 after the shutdown of Canadian Headquarters that provided insight into Canada's cryptomarket scene. There were a number of limits to the data in this study. Data was collected consecutively between June 2021 to January 2022, one cryptomarket at a time, by using the data in the starting pages to find new pages. When there were no links to certain pages or sections from the product home page, such as an inactive vendor with no listings or buyer profile pages, the pages could not be collected.

For sensitive products, such as fentanyl or firearms, vendors and buyers were likely more concerned with security and would use custom listings and reduce their digital footprint. To further reduce the digital footprint, some administrators created a subsection of their market to exclusively sell the information of individual credit cards. This could result in fewer visible reviews for digital products despite digital products

becoming more available and often purchased on newer and younger markets. The data likely underestimates the number of sensitive products and credit card information sold on cryptomarkets.

The results are also likely skewed in favour of the largest cryptomarkets, with WHM contributing to 38.7% of the price data, ToRReZ at 32.2% and World market at 18.8%. The data should still be fairly representative of the overall ecosystem because there is often little variance in the types of products sold on larger cryptomarkets, and larger cryptomarkets facilitate a much larger number of transactions than smaller cryptomarkets.

There were 841,004 unique reviews and 3,825 unique vendors identified across eight cryptomarkets. The eight cryptomarkets and vendors annually sold an estimated \$378.5 million worth of products. Cryptomarkets are expected to grow to include a greater percentage of digital products as cybercrime grows, even if new methods may be necessary to identify these products and sales. Not only are the number of digital listings growing, cryptomarkets have grown to facilitate a larger number of transactions and generated greater revenue in recent years. WHM's income in 2021 was 32.2% more than Dream market in 2018 and 247.5% more than Silk Road in 2013, showing the potential of cryptomarkets to continue growing.

The administrator of the largest cryptomarket, WHM, earned \$11.3 million in the same year. With such a large income, it is no surprise that there are so many new cryptomarkets appearing, there are opportunities for administrators to profit by facilitating illicit trades. These administrators are able to consider the risk and benefits and may have created a crime script for managing their market (Clarke & Cornish, 1985), which can determine when they shut down the cryptomarket. If there are individuals who recognize the opportunities, are willing to participate in facilitating illicit transactions, and have the skills to create new cryptomarkets, it is likely that new cryptomarkets will continue to appear. Some cryptomarkets appeal to users by having additional security features and reducing the risk that they become targets for law enforcement. The administrators that continue to keep their cryptomarket safe and secure are more competitive and thus, more likely to gain vendors and buyers (Xu et al, 2017). As cryptomarkets grow in the number of vendors, buyers, products and currency transferred

on cryptomarkets, they are expected to continue to evolve their security to become more secure.

For cryptomarket administrators to have abundant opportunities, there must be a sufficient number of vendors and buyers willing to utilize new cryptomarkets. The majority of vendors are only available on one cryptomarket, however, they are able to migrate to other cryptomarkets when a cryptomarket shuts down and withstand the associated financial loss (Martin et al., 2020). Some vendors will take on new identities or stop their activities on cryptomarkets, yet the cryptomarkets still strive with the number of vendors available. Of the vendors who remained, they would often migrate onto the second largest cryptomarket, if they do not already have an account there, or other trustworthy markets that appear to the user. The majority of cryptomarkets avoid allowing high-risk products onto their cryptomarket because that could increase the chance their market is targeted, yet trustworthy vendors may still be given the opportunity to sell a product that is perceived as safer. Some cryptomarkets appear to have informally allowed fentanyl patches to be sold because of the perceived reduction in harm (The Recovery Village, 2020), while still banning other forms of fentanyl. The cryptomarket administrators may wish to avoid potential perceived harms that could increase the chance they become a larger target for law enforcement or lose users because of a perceived or real breach of trust.

A few cryptomarkets appeal to users by allowing the sale of high-risk products on their cryptomarket that other cryptomarkets ban, such as firearms and fentanyl, to secure a small community of users who are interested in buying or selling those products. Vendors selling high-risk products have additional security measures in place, such as how firearm products were often sold through custom listings and removing the listing as soon as it is sold. Without the reviews and listings, it is difficult to find information and identify the extent of firearms being trafficked using cryptomarkets. A longitudinal look at cryptomarkets would be required to gain a clearer understanding of firearm trafficking on cryptomarkets.

Drug products accounted for 84.9% of all reviews across the eight cryptomarkets examined. Stimulants were the most often purchased drug followed by cannabis, opioids, and benzodiazepines. Benzodiazepines have been found in a greater number of overdoses, and naloxone is not effective on benzodiazepines (British Columbia

Coroners Service, 2022; Government of Canada, 2021). 51,288 (10.8%) of drug products were benzodiazepines and at least 42.6 kilograms of benzodiazepines were shipped, accounting for 1.0% of the total quantity of drugs shipped. Cryptomarkets have regulations on fentanyl, yet have no regulations on benzodiazepines. These products are not perceived to be as dangerous as opioids, thus, the administrators have not added any restrictions or regulations regarding benzodiazepines. Cryptomarkets could be an important contributor to the sale of benzodiazepines which are appearing in more overdoses in British Columbia.

The price of drug products and the countries they can ship to, found across multiple cryptomarkets, can be used for comparisons between products bought online and those bought from the streets. The cryptomarket price of drug products shipped to Canada was less expensive per gram than street prices in Canada (United Nations Office on Drugs and Crime, 2021b). Other countries may also find that cryptomarkets sell products at cheaper prices than what is available on the streets. The combination of cheaper products, visible reviews, and physical safety may encourage more individuals to start buying products from cryptomarkets.

The price and quantity of the drug package differed between vendors who would offer international shipping and vendors who did not offer international shipping. While the drug type may mediate between if vendors were more likely to ship larger quantities of a product or not, the price was more uniform and less affected by the drug type. Vendors may be less willing to risk the loss of expensive products that could cause a large deficit in their operations. If they offer half a refund when a package is seized, expensive packages are a greater financial risk to their business. If they do not offer refund opportunities, they become less competitive and less attractive to buyers (Xu et al, 2017). There is often greater demand for products across the globe than only within the vendor's country. Vendors must strike a balance between the increase in business associated with selling internationally and their risk tolerance for packages being seized and their reputation lowering.

Vendors are able to learn the regulations and procedures necessary to successfully ship products worldwide after gaining some experience. There are multiple different factors between vendors who ship internationally and those who do not, including experience, the number of drug reviews, the variety of products, and the

number of markets they are available on. Vendors who ship internationally may be searching for a greater number of buyers, thus they tend to be found on multiple markets and can sell a greater variety of products. The downside is that generalist vendors are unpopular for sensitive products and had few to no sales. Buyers may have considered the cost of a specialized product to be too high for the value when compared to specialists (Xu et al., 2017). Vendors shipping internationally would likely need to learn the best practices and strategies to avoid having their packages seized. Offering worldwide shipping increases the potential number of buyers, yet drug vendors are capable of becoming a major vendor without appealing to international buyers. Major vendors were easily accessible and less likely to be impacted by market disruptions, being on twice the number of cryptomarkets than the average drug vendor, and able to attract and retain buyers within their country.

Australia and the United States had an extremely high percentage of drug products that vendors were unwilling to ship worldwide. The shipping regulations for those two countries may have decreased the willingness of vendors to ship products worldwide. Other countries, such as Europe and the Netherlands, have the opposite. The majority of drug products from those countries offered worldwide shipping. The perceived risk by vendors of their products being caught may have been lower in Europe and the Netherlands compared to Australia and the United States. The risk was worth the potential profit. Examination of the shipping procedures in countries where products do not often offer worldwide shipping may offer suggestions as to which policies discourage global drug trafficking. Applying these procedures to Canada could reduce the number of drug products being shipped across Canadian borders and discourage vendors from shipping internationally.

## **7.1. Recommendations and Future Work**

Cryptomarkets have shown rapid growth over the past decade and are likely to continue growing. Products of interest may appear on cryptomarkets and be accessed using cryptomarkets. For products such as luxury goods or forgeries, the shipment of products from cryptomarket vendors could be a gap in research that was not previously accounted for. To reduce this gap, cryptomarkets should be proactively monitored because they are a growing phenomenon that may grow to facilitate a greater number of illicit products being trafficked internationally and domestically. It is important to gain a

greater understanding around the growth and evolution of cryptomarkets to effectively police the cryptomarkets and the activity on them. Examining the traits of successful cryptomarkets and those that are less successful can assist in predicting which cryptomarkets are likely to survive and grow larger compared to those that are not likely.

Vendors tend to privately communicate with individual buyers and personalize firearm listings with the specifics requested by the buyer. These custom listings leave a smaller digital footprint because once the transaction is completed, the listing is taken down and becomes inaccessible. A one-time crawl of a cryptomarket is insufficient to accurately estimate the number of firearm and firearm related products. Cryptomarkets must be examined longitudinally to gain a clearer understanding of the number and nature of firearms trafficking on cryptomarkets, especially the custom listings.

To longitudinally monitor cryptomarkets, a web crawler such as TDC is needed. The initial crawl would take longer because the cryptomarket must be fully crawled. The vendor profiles and number of reviews for products must be able to update every time the crawlers need to collect new information from the cryptomarket. One possible way to do this is to use the vendor profile pages as an index to identify if there have been changes to their products, either in the products available or the reviews on their products. Ensure there is a timestamp to state when the data was collected. Finally, have crawlers log onto cryptomarkets once a day and start data collection by sorting for the most recently added products. New vendors will be added to the vendor list once they post a product listing. When the crawlers run out of new listings and begin to rediscover products they had already collected, the crawlers can move on to updating the vendor's information. By selectively crawling sections of the cryptomarket, the amount of time necessary for each update would be reduced.

Drug products from certain countries have a high percentage of products that cannot ship worldwide, such as Australia and the United States. Other countries have the majority of their drug products capable of shipping worldwide, including Europe and the Netherlands. There are shipping policies and regulations that discourage drug trafficking using cryptomarkets. To reduce the amount of drug trafficking, the shipping policies and regulations of countries that are able to hinder drug trafficking should be examined and compared to countries where drug trafficking is not hindered. Future

research may explore if there are any limits to drug products within Australia or the United States to be shipped to different states of the same country.

Drugs are shipped through mail services such as Canada Post, Xpresspost, and United Parcel Service. Future research can involve working with shipping agencies such as Canada Post and private industries to examine packages and isolate those that match the common practices of cryptomarket drug vendors. Common practices would be identified through a combination of information from dark web forums by what vendors and users recommend as best practices on drug packaging, and physical packages found through Canada Post. Effective search methods would be developed that target packages matching the common practices of drug packaging. The implementation of effective search methods for drug packages would increase the risk of a drug package being identified and seized and can discourage the trafficking of drug products in Canada.

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# Appendix A. Full Drug Index

**Table A.1 Full Drug Index**

Drug	Price per Gram (All)	Price per Gram (Canada)	N
25B-NBOH	\$322.09		54
2C-B	\$21.52		4,141
2F-Viminol*	\$121.41		6
3-Chlorophencyclidine	\$114.77		74
3-Fluoro-Pcp*	\$822.45		1
3-Hydroxyphencyclidine	\$156.09		287
3-Methoxyphencyclidine*	\$77.27		1
4-AcO-EPT	\$131.99		40
4-Fluoroamphetamine	\$111.92		288
4-Fluoromethamphetamine*	\$44.08		14
4-Fluoromethylphenidate*	\$31.02		7
5-Hydroxytryptophan*	\$4.50		2
5-MAPB	\$186.12		39
Aciclovir*	\$1.73		4
Addiction/Overdose Treatment	\$3,546.36		1,674
Alpha- Glycerylphosphorylcholine *	\$1.50		3
Alpha-Phenylacetoacetonitrile*	\$0.16		1
Alprazolam	\$329.38	\$242.11	26,368
Amfepramone*	\$58.05		2
Amitriptyline*	\$43.96		13
Amoxicillin	\$2.88		136
Amphetamine	\$249.16	\$1,446.69	15,612
Anabolic Steroid	\$102.12	\$204.90*	2,615
Anastrozole	\$2,559.16	\$1,166.70*	163
Aniracetam*	\$3.00		7
Antibiotics	\$5.73		193
A-Pyrrolidinoisohexaphenon	\$41.60		75
Aripiprazole*	\$541.93		1
Armodafinil*	\$2.28		17
Atomoxetine*	\$36.11		6
Baclofen	\$49.50		59
Benzocaine*	\$0.35		9
Blend*	\$261.04		2
BOD*	\$226.96		10
Bromazepam	\$312.53		231
Bromazolam	\$414.75		110
Bronchodilator	\$904.65		29

Drug	Price per Gram (All)	Price per Gram (Canada)	N
Buds and Flowers	\$7.39		47,935
Buprenorphine	\$3,634.12		2,202
Bupropion*	\$4.35		
Butonitazene*	\$44.95		1
Cabergoline*	\$4,834.13		6
Cannabinoids	\$6.85		694
Carbamazepine*	\$2.65		4
Cardarine*	\$451.77		9
Carisoprodol	\$3.67		830
Cathinones	\$10.37		60
Citalopram*	\$137.47		13
Clenbuterol	\$1,124.75	\$14,000.00*	268
Clobazam*	\$2,231.00		1
Clomiphene	\$47.53		95
Clomipramine*	\$7.93		3
Clonazepam	\$1,285.81		3,607
Clonazepam	\$107.94		507
Clonidine	\$26,010.25		69
Clorazepate*	\$399.60		2
CNN*	\$15.95		19
Cocaine	\$89.86	\$55.90	59,290
Codeine	\$3.56	\$584.30*	1,988
Concentrates	\$18.76	\$17.10*	5,983
Crack	\$135.00		3,332
Custom Listing*	\$48.38		19
Damiana*	\$0.67		9
Dexmethylphenidate*	\$2,198.45		10
Dextroamphetamine	\$724.39		543
Diazepam	\$176.28	\$0.00	12,045
Diclazepam*	\$395.65		17
Diclofenac*	\$18.71		3
Dihydrocodeine	\$50.08		811
Dimethoxybromoamphetamine*	\$809.40		18
Dinitrophenol	\$3.81		131
Diphenidine*	\$14.06		3
Dipropyltryptamine	\$57.60		24
Dipyanone*	\$32.29		1
Distillate*	\$29.63		7
DMT	\$92.72	\$146.20	6,375
DOB*	\$7,104.00		1
DOC*	\$10,604.50		2
DOM	\$14,931.88		29

Drug	Price per Gram (All)	Price per Gram (Canada)	N
Doxycycline*	\$22.48		9
Duloxetine*	\$29.95		1
Dutasteride*	\$5,349.87		5
Ecstasy	\$13.05	\$22.70*	425
Edibles	\$40.73	\$276.50*	5,113
EDT	\$17.87	\$40.20*	4,952
Ephedrine	\$17.48		165
Ephenidine*	\$151.34		2
Escitalopram*	\$58.04		3
Estradiol*	\$1,126.07		2
Eszopiclone*	\$197.67		14
Ethylone*	\$25.11		1
Etizolam	\$107.66	\$562.50*	1,661
Etodesnitazene	\$151.84		96
Etonitazene*	\$50.44		4
Eutylone*	\$4.62		17
Exemestane	\$139.34		130
Fenofibrate*	\$5.83		1
Fentanyl	\$134.84		811
Finasteride	\$232.48		25
Flualprazolam*	\$108.93		9
Flubromazolam*	\$828.80		1
Flunitrazolam	\$238.23		35
Fluoromethylphenidate	\$36.55		76
Fluoxetine	\$62.06		57
Furosemide*	\$9.53		3
Gabapentin	\$3.41		286
GBL	\$2,260.58	\$980.70*	102
GHB	\$14.55		1,418
Hash	\$11.69		9,259
Haze	\$16.33		236
Heroin	\$73.72	\$127.90	26,416
Hexedrone*	\$17.47		5
Higenamine*	\$696.50		1
Human Chorionic Gonadotropin	\$10.99	\$7.00*	179
Human Growth Hormone	\$1,312.88		59
Hydrochlorothiazide*	\$147.20		3
Hydrocodone	\$1,466.91		1,082
Hydromorphone	\$1,580.62	\$1,333.30	584
Hydroxychloroquine	\$27.67		41
Ibogaine	\$32.08		35
Icariin*	\$2.81		1

Drug	Price per Gram (All)	Price per Gram (Canada)	N
Imipramine*	\$124.63		2
Insulin*	\$41,896.67		4
Isopropylphenidate*	\$33.98		17
Isotretinoin	\$45.89		72
Ivermectin	\$110.80		28
Kanna*	\$1.91		17
Ketamine	\$29.54	\$54.50	12,918
Kratom	\$1.39		90
Lamotrigine*	\$29.31		3
Letrozole	\$1,467.62	\$400.00*	22
Levetiracetam*	\$6.84		1
Levothyroxine*	\$14.90		7
Lidocaine*	\$1.13		17
Liothyronine	\$34,512.43		24
Lisdexamfetamine	\$453.25		106
Lorazepam	\$883.41		1,374
LSD	\$451.78	\$24,693.10*	18,815
Magic Mushrooms	\$6.07	\$3.50	10,270
Masoa Alliacea*	\$2.51		2
MDA	\$54.16	\$21.50*	138
MDMA	\$18.13	\$19.20	25,310
Memantine*	\$16.20		4
Mephedrone	\$7.72		3,838
Mescaline	\$15.26		398
Metaphedrone	\$18.81		75
Metformin	\$0.67		21
Methadone	\$321.96		231
Methamphetamine	\$26.37	\$21.50	23,905
Methaphedrone*	\$19.67		15
Methaqualone	\$31.81		31
Methoxy-Diisopropyltryptamine*	\$292.48		11
Methoxyflurane*	\$73,476.67		1
Methylcybin	\$127.21		76
Methylhexanamine*	\$2,244.00		2
Methylmethcathinone	\$6.00		35
Methylphenidate	\$224.38		2,251
Midazolam	\$340.33		313
Mifepristone*	\$368.98		7
Mimosa*	\$0.16		1
Mirtazapine	\$69.56		20
Misoprostol*	\$3,751.00		2
Modafinil	\$8.47		3,470

<b>Drug</b>	<b>Price per Gram (All)</b>	<b>Price per Gram (Canada)</b>	<b>N</b>
Morphine	\$356.83		854
Nasal Spray*	\$3,744.00		1
Nefiracetam*	\$7.29		2
Nicotinamide*	\$6,540.00		2
Nimetazepam*	\$16.22		2
Nitrazepam	\$378.88		379
Nootropic*	\$279.30		3
Olanzapine*	\$95.68		2
O-methyl-bufotenin	\$420.33		137
Ondansetron*	\$2,788.75		2
Opipramol*	\$15.91		1
Opium	\$51.30		625
Orlistat*	\$8.21		2
Oxandrolone	\$79.00		57
Oxazepam	\$127.50		111
Oxycodone	\$389.17	\$571.70	6,689
Oxymetholone*	\$34.09		3
Oxymorphone	\$3,793.46		29
Paracetamol*	\$2,010.00		1
Peganum Harmala*	\$3.14		10
Peptide*	\$27,867.55		9
Phenazepam*	\$24,160.00		6
Phencyclidine (Pcp)*	\$97.35		14
Phenibut	\$2.57		20
Phenobarbital	\$25.30		21
Phentermine	\$163.45		158
Piracetam*	\$1.16		11
Prazepam*	\$392.01		8
Prednisolone	\$59.74		25
Pregabalin	\$6.71		2,269
Prerolls	\$17.28		65
Proglumide*	\$16.71		16
Promethazine	\$47.34		71
Propofol*	\$67,713.23		8
Propranolol	\$23.49		46
Pyrazolam*	\$24,160.00		16
Quetiapine	\$17.50		67
Raloxifene*	\$60.01		6
RC*	\$224.07		11
Resin	\$11.65		25
Salvia Divinorum	\$2.15		69
Sarm	\$362.04		24

<b>Drug</b>	<b>Price per Gram (All)</b>	<b>Price per Gram (Canada)</b>	<b>N</b>
Seeds	\$95.85		250
Selective Estrogen Receptor Modulator*	\$41.14		11
Sertraline	\$19.28		50
Shake	\$2.19		2,194
Shatter	\$13.73		390
Sibutramine*	\$79.67		12
Speed	\$2.27	\$699.93	24,832
Sumatriptan*	\$24.18		2
Synthetic	\$11.97		316
Syrup*	\$87.61		4
Tamoxifen	\$105.17	\$35.00*	247
Tapentadol	\$32.64		1,147
Temazepam	\$257.02		339
Tilidine	\$113.11		342
Tobacco	\$0.08		141
Tramadol	\$26.39		3,375
Treats Parkinson's Disease*	\$794.70		7
Triazolam	\$510.97		46
Trimethoxyamphetamine	\$289.13		49
Tryptamine	\$406.30		73
Ursodiol*	\$5.41		1
Valacyclovir*	\$2.04		1
Vape	\$48.61		5,655
Weight Loss	\$29.03		53
Yohimbine*	\$123.61		3
Zaleplon*	\$42.73		11
Zolpidem	\$367.77		2,217
Zopiclone	\$168.73		2,529
<b>Total:</b>			<b>408,563</b>

## Appendix B. Cryptomarket Ecosystem Drug Shipping Origin and Destination

**Table B.1 Cryptomarket Ecosystem Drug Shipping Origin and Destination**

Country of Origin	Not Worldwide N (% of source country)	Worldwide N (% of source country)	Total (% of total)
Algeria	2 (100.0%)	0 (0.0%)	2 (0.00%)
Anguilla	1 (100.0%)	0 (0.0%)	1 (0.00%)
Antarctica	2 (100.0%)	0 (0.0%)	2 (0.00%)
Asia	0 (0.0%)	20 (100.0%)	20 (0.00%)
Australia	20,900 (93.9%)	1,369 (6.1%)	22,269 (7.32%)
Austria	114 (47.9%)	124 (52.1%)	238 (0.07%)
Belgium	99 (40.1%)	148 (59.9%)	247 (0.08%)
Bulgaria	19 (9.7%)	176 (90.3%)	195 (0.06%)
Canada	3,296 (63.7%)	1,878 (36.3%)	5,174 (1.70%)
China	0 (0.0%)	44 (100.0%)	44 (0.01%)
Czech Republic	143 (28.9%)	352 (71.1%)	495 (0.16%)
Denmark	0 (0.0%)	43 (100.0%)	43 (0.01%)
Estonia	21 (55.3%)	17 (44.7%)	38 (0.01%)
Europe	827 (14.4%)	4,919 (85.6%)	5,746 (1.88%)
European Union	230 (7.1%)	3,025 (92.9%)	3,255 (1.07%)
France	5,975 (72.8%)	2,234 (27.2%)	8,209 (2.69%)
Germany	26,424 (64.5%)	14,549 (35.5%)	40,973 (13.47%)
Greece	279 (14.6%)	1,629 (85.4%)	1,908 (0.62%)
Holy See (Vatican City State)	0 (0.0%)	25 (100.0%)	25 (0.00%)
Hong Kong	0 (0.0%)	11 (100.0%)	11 (0.00%)
Hungary	2 (14.3%)	12 (85.7%)	14 (0.00%)
India	120 (12.1%)	874 (87.9%)	994 (0.32%)
Ireland	121 (16.0%)	634 (84.0%)	755 (0.24%)
Italy	16 (17.4%)	76 (82.6%)	92 (0.03%)
Latvia	0 (0.0%)	3 (100.0%)	3 (0.00%)
Lithuania	2 (66.7%)	1 (33.3%)	3 (0.00%)
Luxembourg	0 (0.0%)	47 (100.0%)	47 (0.01%)
Mexico	0 (0.0%)	9 (100.0%)	9 (0.00%)
Nepal	0 (0.0%)	65 (100.0%)	65 (0.02%)
Netherlands	3,235 (16.6%)	16,292 (83.4%)	19,527 (6.42%)
North America	2,511 (95.6%)	116 (4.4%)	2,627 (0.86%)
Norway	2 (100.0%)	0 (0.0%)	2 (0.00%)
Poland	1,687 (85.0%)	297 (15.0%)	1,984 (0.65%)
Portugal	1 (100.0%)	0 (0.0%)	1 (0.00%)
Serbia	0 (0.0%)	1 (100.0%)	1 (0.00%)
Singapore	0 (0.0%)	48 (100.0%)	48 (0.01%)

<b>Country of Origin</b>	<b>Not Worldwide N (% of source country)</b>	<b>Worldwide N (% of source country)</b>	<b>Total (% of total)</b>
South Africa	0 (0.0%)	84 (100.0%)	84 (0.02%)
Spain	596 (35.5%)	1,083 (64.5%)	1,679 (0.55%)
Switzerland	1,760 (84.1%)	333 (15.9%)	2,093 (0.68%)
Turkey	255 (100.0%)	0 (0.0%)	255 (0.08%)
United Kingdom	43,359 (55.9%)	34,268 (44.1%)	77,627 (25.52%)
United States	100,168 (95.3%)	4,989 (4.7%)	105,157 (34.58%)
Worldwide	192 (9.0%)	1,943 (91.0%)	2,135 (0.70%)
<b>Total</b>	<b>212,359 (69.8%)</b>	<b>91,738 (30.2%)</b>	<b>304,097 (100.0%)</b>