

**MSc in Crime and Forensic Science**

**Understanding Online Carding Forums:  
On Products, Prices and Sellers**

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## **Abstract**

Underground online forums are platforms that enable trades of illicit services and stolen goods. Carding forums, in particular, are known as being focused on trading of financial information. Little evidence, however, exists as to the sellers that are present on carding forums, the precise types of product they advertise and the prices paid for. Existing literature mainly focuses on the organisation and structure of the forums. Furthermore, the studies on carding forums are usually based on literature review, expert interviews or data from forums that have already been shut down. The aim of this paper is to provide first-of-its-kind empirical evidence on active forums where stolen financial data are traded. Analyses of products, prices, seller prolificacy, seller specialisation and seller reputation are performed. To this end, five out of 25 discovered forums are monitored and advertisements from a three-month's period are collected. These data are analysed quantitatively and qualitatively. Various products with different prices are identified, almost half of the products are credit card numbers. Prices differ with regard to exact product type and issuing country of origin. The analysis further depicts that sales on carding forums are highly unevenly distributed, with a high concentration among a small number of sellers. Specialisation is not a key characteristic of sellers on forums; about one third specialises in a certain product category. The findings also suggest that traders are usually not present on more than one forum. It is hypothesised that the effort needed for gaining trust on each forum might distract users from being active on several forums.

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# 1 Introduction

£479 million of fraud losses on UK issued credit and debit cards were recorded in 2014 (Financial Fraud Action UK 2015). Almost 70% of these losses originate from ‘remote purchase fraud’. This category denotes that card details obtained through illicit methods like phishing, skimming or hacking are used for fraudulent online transactions. Since consumers have shifted from cash to cards and have become accustomed to online payments, opportunities for theft of card details have soared and they have attracted the criminals’ attention.

Theft of card information is the first step in the chain of credit card fraud. Further stages are resale, validation and monetisation of the stolen data. These deals and activities take place in the underground economy and popular platforms where card details are traded are underground online forums. On these forums, fraudsters typically open a thread and write an advertisement for their products as a first posting. Potential buyers either reply within that thread asking to contact them or they contact the seller themselves using private message services or Internet-rely-chat-services like ICQ. The sales volumes thus generated seem to be substantial. It is estimated, for example, that the closure of several credit card related forums in 2012 prevented international fraud in the range of £500 million (Gold 2013). Hence, tackling these forums contributes to significant reductions in financial cybercrime. One prerequisite in this respect is a profound understanding of the characteristics of and the activities on these online forums.

The body of research into underground forums is growing but it is still moderate. As to credit card related forums, in particular, there are only a few studies available. These studies mainly focus on the organisation and the structure of the forums but less on the content itself, which are the products traded and the activities of the traders on these forums. In other words, it is well-known that regulation is necessary to distinguish rippers and legitimate sellers (Allodi et al. 2015) or that formal control and social networking are trade facilitating factors that forums offer (Afroz et al. 2013; Yip et al. 2013). It is less known, however, what is really happening on these forums. In addition, the existing studies are usually based on either expert interviews or examinations of forums that have been shut down. Active forums are rarely analysed. The examination of closed forums may be problematic since they may differ from those still existing, especially when this difference is the reason why they are closed. Moreover, cybercrime evolves rapidly and tackling this type of crime requires an understanding of the *current* situation and activities.

In order to overcome these literature gaps and methodological concerns, the present study aims to shed light on the current situation of underground online forums in analysing real data of active forums. Thereby, the following research question is to be answered: What does the current situation of underground credit card forums look like? That is, what are typical features of the forums, what products are sold and how can the activities of the traders be characterised? With this intention, an outline of active forums and their defining features will be established. A handful of selected forums will then be analysed in detail regarding their traders and products. This investigation will thus provide insights into current underground online forums in order to improve the still limited understanding of these black marketplaces.

The data are collected directly from the discussions on the forums. The focus lies on product offers and advertisements posted by potential sellers on the forums. Buyers or possible money mules are outside the scope. Since sellers come earlier in the fraud chain than the other actors mentioned, it might be more efficient to tackle credit card fraud by stopping sellers than buyers, for example.

The scope of this study is financial cybercrime. This includes digital assets such as stolen credit card details, illegal money transfer or credentials for online payment systems. In contrast, it excludes topics such as hacking, phishing or spamming. Though the data to be analysed might have been acquired through these techniques (e.g. directing email recipients to visit fake online banking sites), the provision of these services themselves is not subject of this paper. The forums which these data are typically traded on are called *carding* forums. Despite their name, not only credit card information is traded there but also the above-mentioned services and goods. Finally, in order to further clarify the scope, online *shops* that sell stolen products are not considered in this examination.

In the following chapter, the existing literature is reviewed and six hypotheses are formulated. In the subsequent methodology-part, the data to be examined and the analyses to be conducted are outlined. Afterwards, the results are presented in detail before implications are explored in the discussion-part.

Overall, the study presents a comprehensive overview of carding forums covering a wide range from small to large examples. Various product types with different prices are identified. The findings suggest that a small number of traders is responsible for the majority of the traffic. A distinct pattern of seller specialisation is yet not discernible.

## **2 Literature review**

Existing literature on underground markets relevant for this study on carding forums will be divided into four sections and is reviewed in the next subchapters: (1) products and prices, (2) seller prolificacy, (3) seller specialisation, (4) seller reputation.

### **2.1 Products and prices**

Main representatives of products and services traded on carding forums are credit card information, account information, credentials or online payment services (Ablon et al. 2014). Motoyama et al. (2011) analysed the records of six closed forums and identified online payments, game-related accounts, credit cards and financial accounts as being the items most traded.

Credit card information is generally split into three groups: credit card numbers, ‘dumps’ and ‘fullz’ (Holt and Lampke 2010). Credit card numbers (aka ‘CVV’) include at least the information printed on the card, that is actual credit card number, cardholder name, expiration date and security code CCV2 on the back side (not to be confused with CVV) and sometimes as well billing address and phone number. These data are used to process online payments. Dumps denote the information from the tracks on the magnetic stripe of a card. These data are required to clone physical credit cards. Fullz, finally, provide further information on the credit card holder including, for example, date of birth or social security number (Holt and Lampke 2010). All these terms are used accordingly hereafter.

In relation to the prices sought for products on carding forums, Shulman (2010) states that, in 2006, credit card numbers were traded for \$1-\$25. Only two years later, numbers were available for \$0.06. Shulman (2010) mentions three reasons that account for this decline: CVVs are becoming a commodity, monetising information is more difficult and credit cards are beset by stolen online credentials. In the April’15 report on Internet security, Symantec (2015) indicates a price range of \$0.50-\$20 for CVVs. These rates, on the one hand, confirm that there are details sold at low prices and, on the other hand, show that there are still cards sold for \$20. That said, all these values should be treated with some caution since both Symantec and Shulman’s employer are private security service providers and may have an interest in reporting biased figures.

Sood and Enbody (2013) provide a more detailed estimation of rates charged per credit card number. Numbers from the USA cost \$4-\$10 on average, from Canada \$5-\$7 and from the UK \$6-\$8. Classified according to credit card types, a classic or standard credit card number from the USA and Canada costs \$8-\$10, a gold card \$15-\$20 and an Amex \$6-\$10. Classic and Amex cards are the cheapest in the listing of Sood and Enbody (2013). Nevertheless, they are still more expensive than the lower limits of their quoted price range (\$4/\$5). In addition to this inconsistency, it is not ideal that these rates have not been observed but estimated and it remains unclear on which basis they have been calculated.

Reasons for price differences are types of cards and country of origin, as already implicated, and as well the rarity and the quantity of the products to be purchased (Hutchings and Holt 2015). Discounts on purchases of large card quantities depress the price per item. Furthermore, cards with more personal information available, with high balances and extended expiration dates and freshly acquired cards tend to be more expensive (Ablon et al. 2014).

Regarding the study at hand, we expect to find roughly the same products traded on running carding forums. As there is no sound information available on the product proportions so far, this study shall provide some insights. There is also no indication given that the prices to be observed will differ significantly although the aforementioned prices are partially based on estimations. For dumps or fullz, the literature does not state reliable prices. As cards containing more information tend to be more expensive than those with less information, however, we infer and hypothesise (**H<sub>1</sub>**) that prices for fullz are higher than those for credit card numbers. In relation to dumps, no hypothesis can be formulated derived from the research literature. Due to the effort needed to monetise the information, low prices would be expected. However, once copied and successfully conducted a transaction, such a clone might be a lucrative means of payment. Also the efforts necessary to steal the data (e.g. skimming dumps in a restaurant vs. collecting data on fake Internet sites) does not give a clear indication of the expected price differences between dumps and CVVs.

## **2.2 Seller prolificacy**

Generally, there are several types of participants on the forums: sellers, buyers, intermediaries, mules, administrators and others. These roles or not mutually exclusive; sellers may simultaneously be buyers. Although the total number of participants is in the dark,

Ablon et al. (2014) argue that, based on expert interviews and literature review, the total number of participants on the forums is likely to rise. The increasingly wide spread of different marketplaces and forums would facilitate the access to one of them. At least from a historic perspective, Christin (2013) would confirm this participant growth on underground platforms as he observed a linear increase of sellers during his half-year's analysis of Silk Road, a large black marketplace. And in the aftermath of Silk Road's take-down in 2013, the number of sellers on competitor- and newcomer-marketplaces has substantially increased, surpassing the original number of sellers on Silk Road (Soska and Christin 2015).

In terms of geographic location, forum users come from all over the world. Regarding the sellers, De Carbonnel (2013) claims that Russian participants would deliver the best quality, participants from China, Latin America and Eastern Europe would be the leaders with respect to quantity. These geographic patterns, however, vary depending on the types of forums and the provided services. An analysis of a marketplace offering SEO services locates the sellers mainly in India, Bangladesh and the USA (Farooqi et al. 2015).

Examinations in relation to sales quantity reveal substantial differences in seller prolificacy. Farooqi et al. (2015, p.5) identified an 'insider ring' composed of several top sellers. This means that a small number of traders accounts for a large part of traffic on the marketplace. One of their common characteristic is that they joined the community very early and are frequent visitors to the page. Christin (2013) agrees on the existence of several long-time sellers but reports also on a continual come and go of sellers. It is unclear, however, whether they leave the community after having made sales or due to unsuccessful attempts.

In terms of seller prolificacy, Motoyama et al. (2011) analysed the records of six closed forums and concluded that 10% of the sellers are responsible for 40-50% of the goods traded. More generally expressed, Décary-Hétu and Leppänen (2013) reason that some sellers are more effective than others. Their conclusion is based on counting of advertisements of sellers on one underground forum. Though, it is doubtful that counting ads is the right approach of quantifying success. Moreover, the analysis of several instead of one forum might have produced more reliable results.

That said, it is common ground among crime scientists that crime is not distributed randomly nor evenly (see for example Felson and Boba 2009). That means, a small group accounts for more offenses than its expected share would be. As seen above, studies on marketplaces and one study based on expert interviews suggest the presence of some highly prolific users. We

hypothesise (**H<sub>2</sub>**) thus that also on running carding forums a small number of traders is responsible for a large proportion of traffic.

### **2.3 Seller specialisation**

Looking at the products sold per seller, several studies found evidence of specialisation amongst sellers. Derived from literature review and expert interviews, Kraemer-Mbula et al. (2013), for example, promote an ecosystem perspective to understand the actions of underground traders. Comparable to the legitimate business community, underground ecosystems would include actors that compete against each other, targeting competitive advantage. They would try to reach this advantage by specialising in a particular type of product.

By applying a framework of social organisation, Holt (2013) identified specialisation on underground forums, too. While one third of sellers offered various products, two thirds focused on only one product category. As the Symantec report (2015) illustrates in more detail, there are perpetrators specialising in writing viruses, in distributing malware or in monetising credit cards, for example. In recent years, Symantec has observed an increasing professionalisation in all aspects in the underground economy. Although Symantec may have an incentive towards over-reporting, their findings are supported by research literature. Sood and Enbody (2013) identified specialisation as a trend in underground markets. They argue that these markets are increasingly accessible to people with various technical skills. Hence, there is a division of labour due to differing skills. Analysing seller characteristics on black marketplaces, also Soska and Christin (2015) discovered numerous specialised sellers. Though, there was as well a notable number of vendors selling different products.

Altogether, specialisation seems to be present in the underground as in the legitimate business world. We hypothesise (**H<sub>3</sub>**) thus that a specialisation is also discernible on carding forums. That is, the majority of the traders sells only one product type.

Thinking a step ahead and referring back to chapter 2.1, what does that mean in terms of product prices? No association between specialisation and product prices was found in the relevant literature. Resorting to economic theories, however, there are long-established economic ‘laws’ (for example Smith 1937). They basically state that concentrating on the production of one task leads to a higher efficiency at that particular task. This efficiency

enables an increase in production compared to unspecialised suppliers. Due to such economies of scale, products and services can be offered at significantly lower cost and prices can be cut. Applied to traders on carding forums, we would expect similar cost- and price-reducing effects when sellers specialise in trading of a single product category. It is thus hypothesised (**H4**) that specialised traders sell their products at lower prices than unspecialised traders.

## **2.4 Seller reputation**

One key aspect in the underground economy is reputation (Ablon et al. 2014; Décary-Héту and Leppänen 2013; Motoyama et al. 2011). A reputable seller is more likely to be trusted and thus more likely to engage in trades and to complete transactions. On forums, reputation is usually established by positive customer feedback. Buyers may rate their sellers by giving positive ratings if the ordered products have successfully been delivered and negative ratings if the seller has not delivered and was rather a probable ripper, instead. As a consequence, a seller's positive reputation score presents his/her threads in a more credible light, and these sellers have a higher chance of acquiring multiple customers (Holt 2013).

Yet the effort to establish baseline reputation appears to be laborious. Before half of traders receive their first positive feedback, for example, they write approximately 60 posts (Motoyama et al. 2011). In this case, the reputation process is intrinsically peer-driven. Sellers are dependent on recommendations by buyers. Sometimes, also the forum administrators provide a vetting process, often in addition to the described peer-driven process and often with intransparent criteria. In those cases, entry cost are relatively high and access to higher tiers is tight (Ablon et al. 2014).

The emphasis on reputation and trust means that it is indispensable for competitive forums to have a well-functioning reputation system. Again, since the above-mentioned findings are widely based on expert interviews and remain therefore relatively vague, the actual status regarding currently running carding forums is not known. Since trades on carding forums depend on relationships between mutually distrustful parties, however, we would argue that trust is even more important than in legitimate trades. In the event of an unsuccessful deal, the parties have hardly any legal remedies and countermeasures available, except for a negative reputation rating. We hypothesise (**H5**) thus that the carding forums to be analysed have working reputation systems that are at least as sophisticated as those of legal marketplaces, as

for instance eBay. This expectation applies only to open forums where everybody can participate. The role of reputation on closed forums or in VIP-sections of open forums is not examined and the findings will thus not be applicable to those forums.

As discussed, the efforts needed for gaining trust are extensive. A consequence might be that sellers concentrate on establishing reputation on one specific instead of several forums. That is, it is not expected that sellers are present on multiple forums. By assuming this, we would confirm Motoyama's et al. (2011) expectation of non-existing multiple accounts. In contrast, we would disagree with Ablon et al. (2014) who argue – without providing any reasons – that sellers would be advertising on multiple marketplaces. We hypothesise (**H<sub>6</sub>**), therefore, that the vast majority of actors is not operating on more than one forum.

## **3 Methodology**

### **3.1 Data overview**

#### **3.1.1 Forum search**

The first step of the examination is the forum search. The following system is applied to find carding forums as thoroughly as possible: Firstly, names of forums that are mentioned by research literature are collected. Secondly, searches via Google are carried out. Thirdly, other search engines and information pages are used, namely Onion.city search via Tor network, webstatsdomain.org and 'The Hidden Wiki'. Finally, forums that have already been found are searched for references to other forums. In this latter case, the method of snowball sampling is adopted (Biernacki and Waldorf 1981). The only selection criterion at this point is that, due to the author's language abilities, the forums have to be at least partly in English or in German.

By this means 25 forums were found, 15 of them via Google. The literature research was of little use since all forums mentioned had already been shut down. Five forums were found by way of other forums and five from listings and other search pages. Although generally numerous forums were listed, most of them did not exist anymore. And also the own analysis of the forums showed that they might close at any time. Two forums discovered at the first search in February 2015 were shut down at the beginning of the analysis in June 2015. Notwithstanding that the carding underworld seems to be dynamic, one active forum was found containing posts dating back to 2008.

Besides forums, more than two dozen stores were discovered (e.g. Globalcards or Dexter, offering mainly credit card numbers). These single-vendor marketplaces are not included in the analysis since they differ significantly from forums. They do not gather multiple sellers, they have no reputation systems and users normally do not communicate with each other. Hence, they do not meet our interest in interactions between forum members.

To narrow down the amount of analysis, five out of these 25 forums (see table 2) are chosen for detailed examination: Altenen, Crdpro, Crimenetwork, Bpcsquad and Tuxedocrew. The first three are the largest forums found (as measured by number of posts) and should thus be the most fruitful ones. Although Agoraforum is the forum possessing the most posts, it is excluded from the analysis because 99% of its posts are requests for referral links for registration on Agora Marketplace. Tuxedocrew is included as it is one of the smallest forums and has existed for around two years. Thus, it is not entirely new and it might provide

interesting insights when its content is compared to that of larger forums. Finally, Bpcsquad is chosen as a medium-sized forum. Remarkable here is that it is the largest one of the very new forums. To sum up, the selection criteria are forum size, date of foundation and, to a lesser degree, content. These criteria should ensure a good mix. In relation to languages, Altenen, Bpcsquad and Tuxedocrew are mainly or exclusively in English, Crimenetwork in German and Crdpro half in English, half in Russian.

### **3.1.2 Temporal sampling**

In order to have a comparable time-coverage of all five forums, activities over a time period of three months are monitored, more specifically from April to June 2015. This means that a snapshot is made by the end of June and data of the previous three months are collected. This three month's period is determined by the largest forum, Altenen. For practical reasons, the expenditure of time needed to analyse this forum and collect the relevant data restricts the time period to be considered.

This limitation to three months entails that no full activity-record can be achieved.

Furthermore, it involves the risk of catching three 'special' months instead of a whole year's coverage. It is argued, however, that the current situation is of interest and not the past and that three months are still more advantageous than even shorter periods. Moreover, the data collection will show that a substantial volume of posts can be captured within three months, especially regarding the larger forums. Admittedly, a longer period would be beneficial for the smaller forums. Though, a consistent and thus comparable time period is favoured over a larger number of ads from small forums.

### **3.1.3 Data collection**

For the total forum overview, information on number of members and posts, content, forum-accessibility, languages and founding dates are collected. For the selected forums, which constitute the subject of the remainder of this chapter, threads where potential sellers advertise their products are collected. A systematic review of the entirety of these forums is not possible. No activity records, copy of databases or web crawler services are available. The analysis is effected from the user's perspective. That means, private messages used to arrange and complete trades, for example, are not analysed. Nevertheless, the chosen method will

provide an enlightening snap-shot of the current carding situation. Where necessary and possible, log-ins are created to gain wider access to the forums.

Threads published between April and June 2015 are collected and pasted into Excel tables for further analysis. Ads that were created before the three month's observation period are basically not collected. However, it is likely that also older threads are still successfully promoting products and generating sales. Therefore, older threads are captured in the cases where an activity in the form of answer postings or vouchings<sup>1</sup> during the three months is registered. These activities suggest that deals have taken place. Indeed, it is crucial that such older threads are also considered since it must be expected that long-established insider rings exist, as pointed out by Farooqi et al. (2015) (see chapter 2.2).

The threads usually describe the advertised products and their prices. When an unspecified price range is indicated in the ad, then always the lowest price is chosen for analysis.

Calculating the mean value may distort the picture presuming that, for example, only one high-priced gold card is offered in addition to mainly low-priced standard cards. Where various products are advertised in a single thread, each entry is considered equally.

To keep the focus on carding, the spectrum of investigation is limited to typical financial cybercrime related data: credit card numbers (CVV), dumps, fullz, PayPal-credentials and Western Union (WU) payment transfers. Other carding-related services such as ordinary online store credentials or monetisation-services are omitted.

In order to operationalise 'traffic' on the forums, as necessary for hypothesis **H<sub>2</sub>**, Décary-Héту and Leppänen (2013) counted advertisements as indicators. In our view, however, the consideration of vouchings would be more promising to obtain an accurate impression of a seller's 'performance'. Vouchings are evident signs that successful transactions have been made. Yet, since probably not every buyer vouches for the seller, counting the number of vouchings tends to underestimate the traffic. Conversely, there might be rippers vouching for each other without having made any transactions. Therefore and since also Farooqi et al. (2015) and Christin (2013) relied on vouchings and member feedbacks, using them to calculate revenues, counting vouchings seems to be an appropriate method.

To determine whether users are specialised in one product category, as a prerequisite to be able to test **H<sub>3</sub>** and **H<sub>4</sub>**, their personal profile sites are checked. These pages allow to display a

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<sup>1</sup> After a successful trade, the buyer usually vouches for the seller by writing a positive feedback-post. Such an entry is called vouching.

complete list of all threads and posts written by the corresponding user. This method enables to see whether multiple products are advertised. The definition of specialisation is relatively strict. Assuming users selling credit card numbers and PayPal-credentials, they are not considered as being specialised. Only very narrowly related categories, as for instance credit card numbers and fullz, are treated as identical product categories in this respect.

Hypothesis **H<sub>6</sub>** requires to determine whether the same users are present on several forums. This user search throughout the selected forums is carried out by a comparison of identity details. If applicable, these are username, email address, ICQ-number and Yahoo-ID. They are collected from the postings and the users' profile pages.

Finally, information on the reputation system of each forum is gathered on various sites. Depending on the forum, these are the FAQs, specially installed forum-threads, terms and conditions or customer information sites. Also own observation and interpretation are employed to grasp the reputation systems' functioning.

In total, 388 threads are collected. They advertise in total 987 individual products. That is, on average, every thread promotes 2.5 individual products (e.g. CVV USA Classic). The figures for the individual forums are depicted in table 1.

|                     | <b>Threads</b> | <b>Individual products</b> |
|---------------------|----------------|----------------------------|
| <b>Altenen</b>      | 206            | 431                        |
| <b>Crdpro</b>       | 57             | 270                        |
| <b>Crimenetwork</b> | 96             | 136                        |
| <b>Bpcsquad</b>     | 25             | 130                        |
| <b>Tuxedocrew</b>   | 4              | 20                         |

Table 1: Threads and individual products per forum

### **3.2 Analytical strategy**

The monitoring of the forums requires a combined methodical approach. The content will be both qualitatively (for content categorisation and analysis of reputation) and quantitatively (for comparisons of products and prices and for determination of traffic per seller) analysed.

To prepare the data for analysis, a categorisation of the thread contents is necessary. This procedure requires a qualitative research approach and is thus done manually in Excel using content analysis method. In terms of reliability it is important to stick to clear coding rules in order to avoid subjective and inconsistent categorisations. As far as validity is concerned, manual coding is an advantage since it enables to measure exactly the content the researcher wants to target (Gibbs 2008). Some approximate categories have already been provided by the research literature (e.g. 'credit cards'). However, these categories are somewhat too coarse and further sub-categories have to be created (e.g. 'CVV' or 'dumps'). Hence, the categorisation is a combined product of deductive (assign content to given categories) and inductive (build new categories based on content) practice (Kluge 1999). Yet, it is important to consider that the categories do not become too small and thus do not render impossible subsequent quantitative calculations. For example, dumps are sometimes advertised divided into track 1 or track 2 dumps. Since the aim of the categorisation is to obtain *meaningful* product categories, such fine distinctions are avoided. Eventually, this means that credit card data are coded according to product category, country and product type (e.g. CVV, UK, gold). Visa and Mastercard details are not explicitly differentiated since they are usually treated interchangeably by the traders.

Next, the data are imported into SPSS-software in order to conduct statistical analyses. At first, general frequency calculations are run. In order to test hypothesis **H<sub>2</sub>**, the number of traders in relation to the generated traffic is quantitatively computed in the shape of a Lorenz curve. For **H<sub>3</sub>**, the frequencies of the users that are specialised are compared to those who are not. **H<sub>1</sub>** and **H<sub>4</sub>** require the application of inference statistics. Since their price distributions resemble more a Poisson- than a normal distribution, Mann-Whitney-U-tests are performed to test whether there are significant differences between the values. Regarding **H<sub>5</sub>**, the reputation systems of the forums are evaluated qualitatively. To assess the degree of sophistication in relation to legitimate marketplaces, they are contrasted to eBay's system. Strictly speaking, eBay is not a forum and thus not fully comparable. However, there are no suitable legitimate large-scale forums that are set up to enable trading. Furthermore, eBay comes close to the system of advertising, trading and buying exercised on forums and, as being a leading marketplace, it is further expected to have a state-of-the-art reputation system. Finally, in order to examine whether sellers are operating on more than one forum (**H<sub>6</sub>**), the proportions of multiple representations across all forums are reproduced and interpreted.

All these calculations are conducted both for the entirety of the threads and for each forum separately. Therefore, results are reported in aggregated form and, if applicable and if enough cases are available, for every individual forum.

## 4 Results

### 4.1 Overview of forums

Table 2 provides an overview of the 25 discovered forums. It contains the following headings:

- *Name*: This column lists the names of the forums. The full website addresses are depicted in the appendix (table A1). They have a wide array of top-level domains, for example usual ones like .com or .net and exotic ones like .ws (Samoa) or .so (Somalia). The locations the forums really operate from are usually not clear and, apart from two German speaking platforms, cannot be derived from the forum content.
- *Members*: The indicated figures are the number of members by June 2015, reaching from 1100 to 148,800 members. A comparison between the first search in February and the second in June reveals some substantial increases in members. Cardersforum, for example, grew from 44,200 to 45,700 (plus 3.4%), Cardingmafia from 98,700 to 121,500 (plus 23.1%) members. Altenen, already a large forum in February, was more than twice as large four months later (from 60,700 to 148,800, plus 145.1%).  
It is not clear how many of the members on each forum are actually contributing. Two forums, though, indicate in their forum statistics that only a fraction is really active. On Altenen, these are 38,300 of its 148,800 members (25.7%); on Carder, these are 1500 of 10,200 (14.7%). Both forums do not disclose what ‘active members’ actually means.
- *Total posts*: The number of posts varies between 150 and 15,778,599. Besides advertisements, the posts consist mainly of answers to advertisements or of contributions to discussions. Typical answers to offers for sale are ‘interested please contact me’ or ‘made deal and worked’. In line with the number of members, also the number of posts increased between the two searches (e.g. Cardingmafia from 31,900 to 37,600 posts, plus 17.9%). Altenen doubled the number of posts (from 607,100 to 1,265,500, plus 108.5%).
- *Content categories*: This column describes the main content of the forums in a non-hierarchical sequence. Obviously, each forum includes a carding part. That does not imply, however, that carding is the main part of the forum. Where ‘NA’ is stated, there are links on other forums indicating that these forums must contain a carding part.

Table 2: Overview of carding forums

| Name                | Members | Total posts | Content categories                                      | Accessibility    | Languages | Founded |
|---------------------|---------|-------------|---|------------------|-----------|---------|
| Agoraforum          | 56300   | 15778599    | Carding, narcotics, accounts                            | open             | EN        | 2013    |
| <b>Altenen</b>      | 148800  | 1265500     | Cardings, accounts, anonymity                           | open             | EN        | 2013    |
| <b>Crdpro</b>       | 103600  | 1102300     | Carding, anonymity, hacking, spamming                   | VIP-area         | EN, RU    | 2009    |
| <b>Crimenetwork</b> | 57300   | 1065400     | Carding, hacking, accounts, narcotics, various products | VIP-area         | GE        | 2012    |
| Cardingforum        | 74000   | 486800      | Carding, hacking, spamming                              | VIP-area         | EN, RU    | 2008    |
| Hackingforum        | 72200   | 228300      | Carding, hacking, anonymity                             | VIP-area         | EN        | 2012    |
| Unixorder           | 43500   | 217100      | Carding, Windows applications, movies                   | open             | EN        | 2011    |
| Crdclub             | 36200   | 178900      | Carding, anonymity, hacking                             | open             | EN, RU    | 2013    |
| Carderscave         | 21500   | 174400      | Carding, hacking  | VIP-area         | EN, RU    | NA      |
| Infraud             | 10500   | 82200       | NA  | registration fee | EN, RU    | NA      |
| Lampeduza           | 4300    | 76600       | Carding, anonymity, programming, hacking, SEO           | registration fee | EN, RU    | 2011    |
| Blackstuff          | 78600   | 70500       | Carding, hacking, anonymity, programming                | VIP-area         | EN        | 2011    |
| Bus1Nezz            | 5100    | 45800       | Carding, accounts, narcotics, various products          | open             | GE        | 2013    |
| Cardingmafia        | 121500  | 37600       | Carding, hacking, anonymity, programming, accounts      | VIP-area         | EN        | 2010    |
| <b>Bpcsquad</b>     | 6100    | 32300       | Carding, anonymity, programming                         | open             | EN        | 2014    |
| Procarder           | 115400  | 29400       | Carding, accounts                                       | VIP-area         | EN, RU    | 2010    |
| Cardersforum        | 45700   | 25000       | Carding, hacking  | VIP-area         | EN        | 2012    |

Table 2 (cont.): Overview of carding forums

|                   |       |       |  |                  |        |      |
|-------------------|-------|-------|--|------------------|--------|------|
| Crimes            | 9700  | 17600 | Carding, hacking, spamming                         | VIP-area         | EN     | 2013 |
| Carderbase        | 10900 | 6900  | Carding, hacking                                   | open             | EN, RU | 2012 |
| Carder            | 10200 | 5100  | Carding, hacking, SEO                              | VIP-area         | EN, RU | 2013 |
| Darkstuff         | 2500  | 4700  | Carding, hacking, anonymity, programming           | VIP-area         | EN     | NA   |
| Coinodeal         | 2000  | 4300  | Carding, anonymity, programming, hacking, spamming | VIP-area         | EN     | 2014 |
| <b>Tuxedocrew</b> | 1100  | 800   | Carding, hacking, spamming                         | open             | EN     | 2013 |
| Privatemarket     | 1500  | 150   | Carding, hacking                                   | open             | EN     | 2014 |
| Omerta            | NA    | NA    | NA   | registration fee | EN, RU | NA   |

- *Accessibility*: Nine forums are completely open. This means that everybody can access the forum, be it with free or even without registration. More than half of the forums have a private VIP area where users need a special registration. In order to get access to these areas, users usually require a recommendation or an invitation by other members. Three forums charge a registration fee of \$50 (Lampeduza) or \$100 (Infraud and Omerta), respectively.
- *Languages*: The forums are mainly in English and in Russian, two are in German. Some forums contain as well international sections in various languages. However, the posts there are consistently of marginal number.
- *Founded*: The entered dates for the starting points of the forums are a vague indicator. The dates are derived from the oldest posts found on the forums, mostly in the introduction or announcement sections. These are not necessarily the founding dates as older posts might have been deleted in the meantime. In addition, forums might have been shut down and reopened under another name (e.g. Crdpro is former Carderpro). The overview shows dates between 2008 and 2014. The largest proportion was launched in 2013.

Overall, there is a wide variety of forums. In terms of size, the median number of members is 28,850, the median number of posts is 58,150. Excluding the special case of Agoraforum, the number of posts per member varies between 0.1 (Privatemarket) and 18.6 (Crimenetwork). There are thus forums where only a fraction of the members posts messages and there are some where members post numerous messages on average. Though, all these results have to be treated with caution as posts or members might have been deleted during the existence of the forums.

## **4.2 Detailed analysis**

### **4.2.1 Products and prices**

These subchapters under 4.2 present the results of the hypotheses testing for the five selected forums. Table 3 depicts the numbers, proportions (in %) and prices (in US\$) per product category. CVVs are further divided into product type.

Credit card numbers cost on average \$10, dumps and fullz more than \$30. PayPal credentials are advertised for \$3. Western Union payments of \$100 are sold for \$15. As hypothesised (**H<sub>1</sub>**), prices for fullz are higher than those for credit card numbers (CVV: mean = 10.08,

median = 10.00; fullz: mean = 31.82, median = 30.00). The difference is statistically significant (Mann-Whitney-U = 4011,  $z = -12.86$ ,  $p < 0.01$ ).

| <b>Products</b>    | <b>Number</b> | <b>Proportion (%)</b> | <b>Price (\$)</b> |
|--------------------|---------------|-----------------------|-------------------|
| <b>CVVs</b>        | 465           | 47.1                  | 10.08             |
| <i>Classic</i>     | 98            | 9.9                   | 9.93              |
| <i>Gold</i>        | 14            | 1.4                   | 16.86             |
| <i>Amex</i>        | 66            | 6.7                   | 12.34             |
| <i>others</i>      | 16            | 1.6                   | 13.00             |
| <i>unspecified</i> | 271           | 27.5                  | 9.06              |
| <b>Dumps</b>       | 234           | 23.7                  | 34.52             |
| <b>Fullz</b>       | 140           | 14.2                  | 31.82             |
| <b>PayPal</b>      | 133           | 13.5                  | 3.01              |
| <b>WU (\$100)</b>  | 15            | 1.5                   | 15.00             |
| <b>Total</b>       | 987           | 100.0                 |                   |

Table 3: Products and prices (mean) in total

Examined per individual forum, prices for CVVs do not vary substantially, those for the other products see considerable variation (see table 4). Besides price differences, also the product proportions per forum vary. On Altenen, for example, dumps have a share of 8% of the products analysed. On Crdpro, their proportion is 52%. Yet, the absolute numbers are partly very low and the values may thus lack reliability. Western Union is totally omitted due to low numbers.

The prices per product category depend widely on the effective composition of these categories, that is on the relative frequencies per product type and country of origin. Since the absolute numbers are too low to display these values for each forum, table 5 shows them summarised across all forums. Only product types consisting of at least 10 cases are considered. There is indeed substantial variation between different product types and countries. Amex and gold cards are consistently more expensive than classic VISA or Mastercard cards. US products are the cheapest, European tend to be the most expensive.

| <i>Altenen</i> | <b>Number</b> | <b>Proportion (%)</b> | <b>Price (\$)</b> |
|----------------|---------------|-----------------------|-------------------|
| <b>CVV</b>     | 236           | 55.0                  | 9.71              |
| <b>Dumps</b>   | 36            | 8.4                   | 24.10             |
| <b>Fullz</b>   | 63            | 14.7                  | 26.36             |
| <b>PayPal</b>  | 94            | 21.9                  | 3.61              |
| <b>Total</b>   | 429           | 100.0                 |                   |

| <i>Crdpro</i> | <b>Number</b> | <b>Proportion (%)</b> | <b>Price (\$)</b> |
|---------------|---------------|-----------------------|-------------------|
| <b>CVV</b>    | 102           | 38.5                  | 10.80             |
| <b>Dumps</b>  | 138           | 52.1                  | 36.91             |
| <b>Fullz</b>  | 17            | 6.4                   | 31.08             |
| <b>PayPal</b> | 8             | 3.0                   | 5.69              |
| <b>Total</b>  | 265           | 100.0                 |                   |

| <i>Crimenetwork</i> | <b>Number</b> | <b>Proportion (%)</b> | <b>Price (\$)</b> |
|---------------------|---------------|-----------------------|-------------------|
| <b>CVV</b>          | 73            | 53.7                  | 8.69              |
| <b>Dumps</b>        | 5             | 3.7                   | 38.40             |
| <b>Fullz</b>        | 32            | 23.5                  | 40.51             |
| <b>PayPal</b>       | 26            | 19.1                  | 2.66              |
| <b>Total</b>        | 136           | 100.0                 |                   |

| <i>Bpcsquad</i> | <b>Number</b> | <b>Proportion (%)</b> | <b>Price (\$)</b> |
|-----------------|---------------|-----------------------|-------------------|
| <b>CVV</b>      | 48            | 38.7                  | 10.90             |
| <b>Dumps</b>    | 46            | 37.1                  | 31.52             |
| <b>Fullz</b>    | 25            | 20.2                  | 22.48             |
| <b>PayPal</b>   | 5             | 4.0                   | 34.00             |
| <b>Total</b>    | 124           | 100.0                 |                   |

| <i>Tuxedocrew</i> | <b>Number</b> | <b>Proportion (%)</b> | <b>Price (\$)</b> |
|-------------------|---------------|-----------------------|-------------------|
| <b>CVV</b>        | 6             | 33.3                  | 11.67             |
| <b>Dumps</b>      | 9             | 50.0                  | 46.44             |
| <b>Fullz</b>      | 3             | 16.7                  | 36.67             |
| <b>PayPal</b>     | 0             | 0.0                   |                   |
| <b>Total</b>      | 18            | 100.0                 |                   |

Table 4: Products and prices (mean) per forum

|                |                  |                | <b>Number</b> | <b>Price (\$)</b> |
|----------------|------------------|----------------|---------------|-------------------|
| <b>CVV</b>     | <b>Australia</b> | <b>Classic</b> | 12            | 12.75             |
|                | <b>Canada</b>    | <b>Amex</b>    | 10            | 14.20             |
|                |                  | <b>Classic</b> | 14            | 10.92             |
|                | <b>UK</b>        | <b>Amex</b>    | 10            | 15.10             |
|                |                  | <b>Classic</b> | 17            | 11.94             |
|                | <b>USA</b>       | <b>Amex</b>    | 25            | 7.02              |
| <b>Classic</b> |                  | 31             | 5.46          |                   |
| <b>Dumps</b>   | <b>Canada</b>    | <b>Classic</b> | 14            | 31.43             |
|                |                  | <b>Gold</b>    | 12            | 45.25             |
|                | <b>EU</b>        | <b>Classic</b> | 20            | 41.75             |
|                |                  | <b>Gold</b>    | 20            | 58.50             |
|                | <b>USA</b>       | <b>Classic</b> | 29            | 19.17             |
|                |                  | <b>Gold</b>    | 27            | 30.93             |

Table 5: Products and prices (mean) per product type with more than 10 cases

#### 4.2.2 Seller prolificacy

The products are not sold evenly throughout all sellers on the forums. The Lorenz curve in figure 1 shows that around 70% do not generate any obvious traffic as seller whereas a single user generates 44% of all traffic. This user joined Altenen in summer 2014 and sells CVVs of various countries.

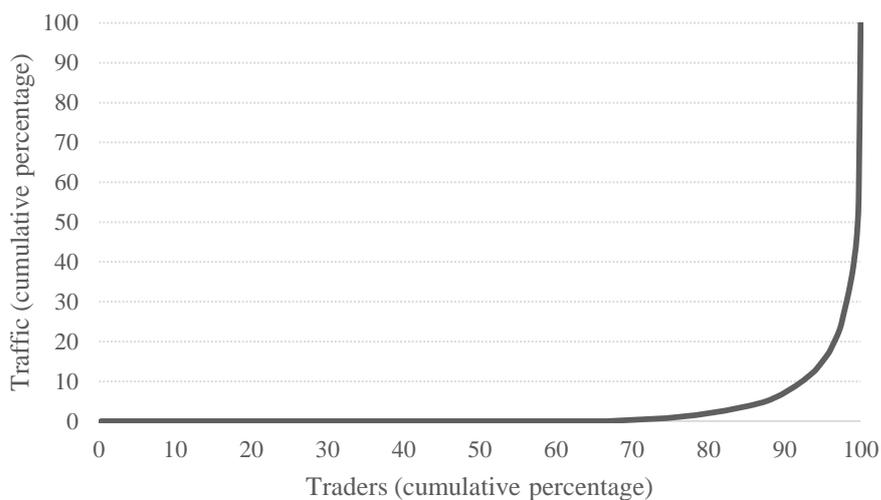


Figure 1: Lorenz curve indicating cumulative percentage of traders against cumulative percentage of traffic (all forums)

Disentangling the individual forums from the total results in similar pictures (figures 2–4). Altenen has the most unequal distribution. Crimenetwork’s distribution is not as extreme but still far from being equal. Bpcsquad and Tuxedocrew have too few vouchings to calculate a Lorenz curve. Though, Tuxedocrew has ads dating back to 2013 that still receive vouchings but only in small numbers.

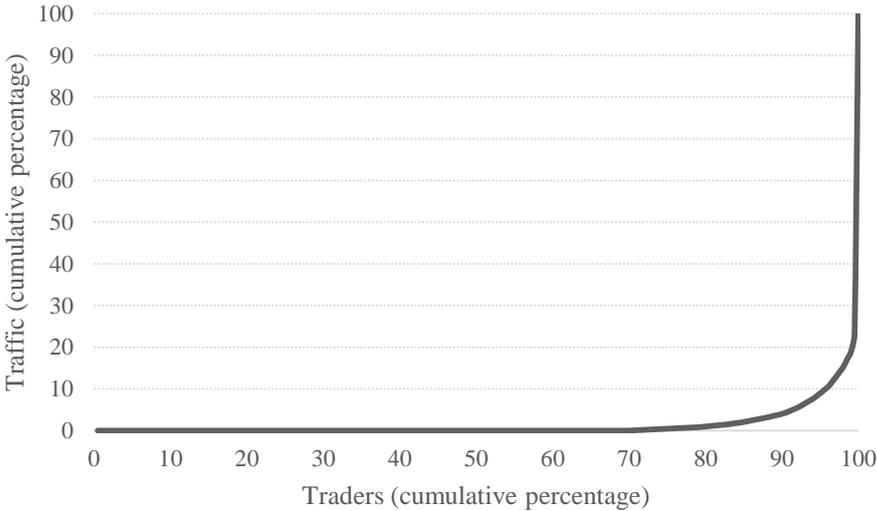


Figure 2: Lorenz curve indicating cumulative percentage of traders against cumulative percentage of traffic (Altenen).

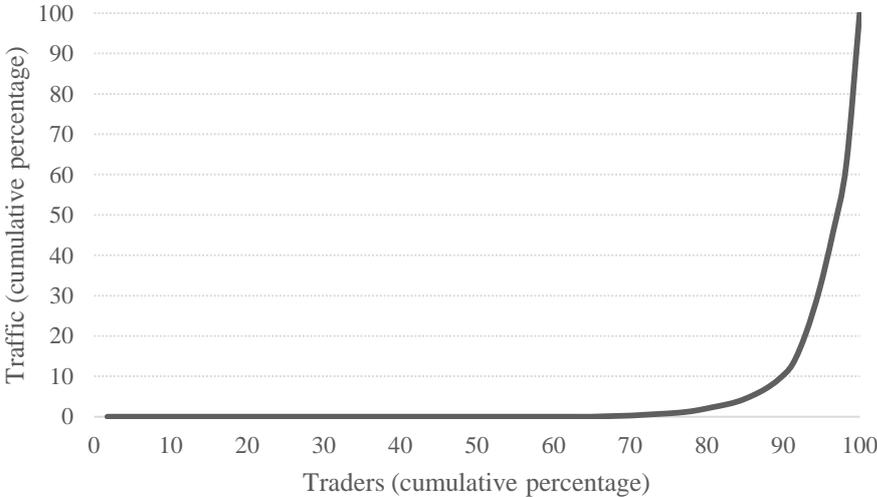


Figure 3: Lorenz curve indicating cumulative percentage of traders against cumulative percentage of traffic (Crdpro).

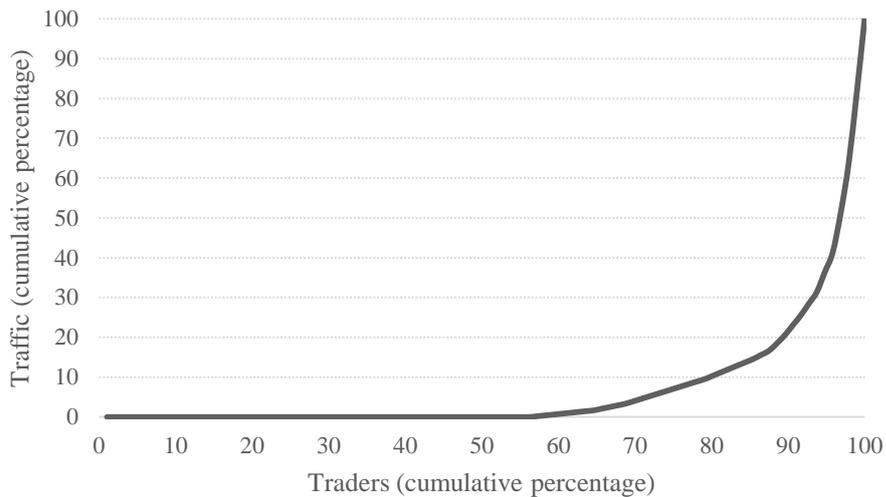


Figure 4: Lorenz curve indicating cumulative percentage of traders against cumulative percentage of traffic (Crimenetwork).

Crdpro does not diverge from these distributions. Considering the total amount of traffic, however, it is striking that the figures are low, both in the English and in the Russian speaking part. Although Crdpro has 17 times as many users as Bpcsqad, for example, it produced only twice as many advertising threads during the time of observation. Detailed analysis reveals that a substantial number of these threads contains links to shops. Furthermore, there have been no new entries in the two VIP areas since 2013 and the forum seems to have been disconnected during some summer months in 2013.

In terms of products, the top three sellers on Altenen sell CVVs and WU payments, on Crdpro they sell dumps and on Crimenetwork again CVVs. As far as reputation is concerned, the high-profile sellers have usually high reputation ratings.

To conclude this subchapter, the hypothesis (**H<sub>2</sub>**) that a small number of traders is responsible for a large proportion of traffic is accepted. However, the presence of an insider ring, as proposed by Farooqi et al. (2015), cannot be confirmed. Overall, only five out of the twenty most prolific users registered in the founding year of the according forum. The others joined later. Although it is possible that some sellers have more than one account and have thus several 'joining-dates', this possibility does not seem to be very likely, mainly due to the expected effort needed for establishing reputation for each account.

### 4.2.3 Seller specialisation

In total, the majority of the users on the forums is not specialised (see table 6). That is, the majority sells more than one type of product and hypothesis **H<sub>3</sub>** has to be rejected.

|                     | Specialised users |                | Unspecialised users |                |
|---------------------|-------------------|----------------|---------------------|----------------|
|                     | Number            | Proportion (%) | Number              | Proportion (%) |
| <b>Altenen</b>      | 64                | 31.1           | 142                 | 68.9           |
| <b>Crdpro</b>       | 41                | 73.2           | 15                  | 26.8           |
| <b>Crimenetwork</b> | 24                | 25.0           | 72                  | 75.0           |
| <b>Bpcsquad</b>     | 15                | 60.0           | 10                  | 40.0           |
| <b>Tuxedocrew</b>   | 3                 | 100.0          | 0                   | 0.0            |
| <b>Total</b>        | 147               | 38.1           | 239                 | 61.9           |

Table 6: Number and proportion of specialised and unspecialised users per forum and in total

Regarding Crdpro, Bpcsquad and Tuxedocrew, the hypothesis would be true. A closer look on Crdpro reveals, however, that its users generally sell a large variety of the same product category, instead, as for instance credit cards from many different countries. This pattern is exactly the opposite of Crimenetwork's. Users on Crimenetwork usually do sell different product categories but not various types within the same product category, for example only CVVs from Germany.

The results for **H<sub>3</sub>** raise the question about differences between specialised and unspecialised sellers. Building upon **H<sub>2</sub>** and taking into account the number of vouchings these users receive, no major differences are discernible. Regarding Altenen, for example, seven out of the twenty users with the most vouchings are specialised. This equals approximately the calculated specialisation rate of 31%.

In terms of prices per product, there are some differences. CVVs, dumps and PayPal-credentials advertised by specialised users are cheaper than those of unspecialised users; fullz are more expensive (see table 7). However, only the price difference for dumps is statistically significant at the 95% confidence level (Mann-Whitney-U = 1643,  $z = -4.83$ ,  $p < 0.01$ ).

Hypothesis **H<sub>4</sub>** has thus to be partially rejected.

That said, it is delicate to summarise product types because every type and country has its own price. A careful comparison would only contain a single product type. Hence, such a

price comparison is executed for US Classic CVVs, the most prevalent product type. The result shows no significant difference (Mann-Whitney-U = 54,  $z = -0.63$ , n.s.).

|               | Specialised users |                |            | Unspecialised users |                |            |
|---------------|-------------------|----------------|------------|---------------------|----------------|------------|
|               | Number            | Proportion (%) | Price (\$) | Number              | Proportion (%) | Price (\$) |
| <b>CVV</b>    | 166               | 39.1           | 9.28       | 299                 | 54.7           | 10.46      |
| <b>Dumps</b>  | 193               | 45.4           | 32.56      | 41                  | 7.5            | 42.61      |
| <b>Fullz</b>  | 45                | 10.6           | 35.86      | 95                  | 17.4           | 30.20      |
| <b>Paypal</b> | 21                | 4.9            | 1.99       | 112                 | 20.5           | 3.17       |
| <b>Total</b>  | 425               | 100.0          |            | 547                 | 100.0          |            |

Table 7: Number, proportion and price of product categories per specialised and unspecialised users

A striking aspect which table 7 reveals is the distribution of advertised product categories among specialised and unspecialised users. Unspecialised users hardly advertise any dumps (7.5% of all products). In contrast, dumps are almost half of the products (45.4%) that specialised users advertise.

#### 4.2.4 Seller reputation

It was hypothesised (**H<sub>5</sub>**) that the carding forums have working reputation systems at least as sophisticated as those of legal marketplaces. The reputation systems look as follows:

- *eBay*: Buyers on eBay can leave feedback for a seller after a purchase and transaction ends. These ratings determine the ‘feedback score’: A positive feedback gives one point, a neutral does not change the score and a negative subtracts one point (<http://pages.ebay.co.uk/help/feedback/howitworks.html>). As an additional protection measure, eBay refunds the purchase price in the event of a non-delivery (‘money-back-guarantee’, <http://pages.ebay.co.uk/ebay-money-back-guarantee/>). Furthermore, a seller protection service identifies high-risk buyers in order to avoid non-payments (<http://portal.ebay.co.uk/seller-protection/>).
- *Altenen*: Altenen’s basic reputation system works in the same way as eBay’s. A user’s ‘reputation power’ consists of the number of positive minus the number of negative feedbacks. The median score of the observed sellers is 1. In addition, users are allowed to rate threads. Sellers have also the opportunity of paying \$50 to the ‘Altenen buyer

protection reserve' that is used as backup payment service. In case of a non-delivery, buyers receive their money back out of this fund. Altenen offers also an escrow service that protects buyers from non-delivery and sellers from non-payment. In using that service, a buyer pays the money plus a transaction fee of \$5–\$30 to Altenen. Once the requested products are delivered, the amount is released to the seller.

- *Crdpro*: In theory, Crdpro has the identical feedback system as Altenen does. However, the system is disabled. As a consequence, apart from some long-standing members, all other members have a neutral feedback score. An escrow service is not provided.
- *Crimenetwork*: Crimenetwork's reputation system is based on 'likes', similar to Facebook. Members may 'like' other members. Like-scores between 0 and 857 are recorded with a median of 36 likes. Crimenetwork's escrow service is comparable to Altenen's. A fee of 4% of the purchase price is charged for successful transactions.
- *Bpcsquad*: As seen with Altenen and Crdpro, members may rate other members on Bpcsquad by giving positive, neutral or negative feedback. The scores reach from 0 to 80, with a median of 0. Furthermore, there is a thread rating possibility. Bpcsquad has also activated an escrow service but does not provide information on transaction fees.
- *Tuxedocrew*: Tuxedocrew's reputation system differs from those seen so far. Users can only rate threads but cannot give any feedbacks for other users. Instead, the forum administrator can award users with special titles. The criteria that have to be met to receive these titles are not published on the forum. Tuxedocrew offers as well an escrow service and charges a 15% fee.

Overall, only Altenen's system appears to be similarly elaborated as eBay's. However, it has an amateurish touch, especially the \$50 buyer protection reserve which is not able to cover substantial amounts. The other forums have fewer features than eBay and even those are not always working. **H<sub>5</sub>** is thus rejected.

As final part in this chapter, it is examined whether users are present on several forums. This is done for all kind of sellers including high- and low-profile traders. In total, only six users are found to be trading on more than one forum, namely two on Altenen and Crdpro, two on Altenen and Bpcsquad and two on Bpcsquad and Crdpro. A detailed analysis of these users shows that they are not high-profile but rather low-profile, unsuccessful traders trying their luck on several platforms. Hypothesis **H<sub>6</sub>** is thus confirmed; a concentration on single forums has been expected.

## 5 Discussion

The prices sought for the products offered on the forums lie within the range given by the reviewed literature. In detail, especially dumps and fullz are relatively expensive; they are more than three times as expensive as credit card numbers (CVVs). This may be due to the effort needed to gain or monetise the data, the amount of information available, the higher rewarding potential and differing demand and supply. Brison (2015) argues, for example, that dumps generally promise a higher payoff than CVVs. In contrast, CVVs are well-represented on the forums and seem thus to be available in abundance what might push prices downwards. However and contrary to Shulman's (2010) assumption, also the prices for CVVs are still solid. And taking into account the large proportion of CVVs on the investigated forums, trading credit card numbers is presumably still a lucrative business. PayPal-credentials are well-represented on some forums, too but, so far, do not seem to replace credit cards as most attractive trading goods. Western Union money transfer services play only a marginal role on the majority of the forums.

The products are advertised by sellers with varied success. Whereas some users complete hundreds of transactions, the majority does not sell anything at all. This means that the trading sections of the forums are profitable distribution channels for high-profile actors. The domination by a few traders implies that the forums do not tend to be typical forums characterised by mutual exchanging and participating users. In the carding world, there is somewhat a clash of prolificacy and – arguably – professionalism observable.

Referring back to the methodology part, counting of vouchings instead of ads, the latter proposed by Décary-Hétu and Leppänen (2013), was probably more suitable to determine criminal performance. Some prolific sellers had only one ad but received dozens of vouchings. Counting of ads would have overlooked that.

As seen, specialisation is not a key characteristic of sellers, even not of high-profile traders. Specialisation was observed most on Crdpro. This might be due to the high proportion of dumps sold on this forums. Dumps constitute almost half of the products sold by specialised users. Dealing with dumps appears to demand a higher degree of specialisation than dealing with only electronically obtainable products. Unlike CVVs or credentials, the acquisition of dumps requires a connection to the physic world. Therefore, perpetrators cannot stay in the underground cyberworld only. As a result, it might be more costly for unspecialised users to acquire dumps and, thus, they have to sell them at higher prices, what would confirm Smith's (1937) theory.

Yet the majority of sellers is not specialised. It could be argued that if they are apt or have valuable data sources, they know and distribute also other types of illicit products and services. On the contrary, unsuccessful sellers try their luck with another product if it does not work with the first. These users, though, might as well be rippers. Advertising a large array of products might intend to give the impression of a prosperous seller. Or they just try various products in the hope that somebody would engage in a trade eventually.

Overall, it is likely that the scope of analysis regarding specialisation was too narrow. There may be a specialisation in the underground world in larger terms where carding itself is already a specialisation. Another reason might be that carding is not as complicated as other cybercrimes like DDoS-attacks or large-scale spam campaigns. Regarding DDoS-attacks, for example, taking advantage of security vulnerabilities and forcing compromised machines to send huge amounts of data may require more time and skills than stealing and trading credit card data. Therefore, it makes more sense to be specialised in those domains.

At least on the investigated forums and given the available details, users are not present on more than one forum. It might thus be true that the effort needed to reach a certain reputation level deters users from establishing themselves on multiple forums, as Motoyama et al. (2011) proposed. This very effort could also be the reason that most users do not have any ratings at all, as the analysis showed. Another reason for this, however, might also be the presence of rippers. Regarding users with high reputation and many vouchings, it is highly unlikely to find any rippers among them. Among users without any reputation scores and vouchings, the proportion of rippers could be large. One expert interviewed by Ablon et al. (2014) estimates that around 30% of all sellers are rippers.

In general and if not stated otherwise, all the findings apply to all five examined forums. Though, there are some differences. Sales on Crimenetwork are not distributed as extremely unevenly as on other forums, neither are there numerous specialised users present. Various people are selling various goods. Crimenetwork is thus more forum-like in terms of mutual exchange and participation than the other forums. The high number of posts per member confirms this perception. In addition, the forum makes a well-maintained impression. It has a myriad of banned users and the administrators comment rigorously if users do not stick to the rules (e.g. in case a post does not fit into a thread).

Crdpro is the obvious opposite. Its best times were probably in the past; the forum appears to be in decline. It does not seem to be monitored by the administrators, there is no escrow

service, the reputation system is not working and there is in general not much traffic. It might be a question of time until the entire forum will be closed.

On Tuxedocrew, the smallest forum, there are only four recorded threads receiving any vouches. However, the number of vouchings are low and it is thus questionable how fruitful the business really is. What might be possible is that some recurring customers buy a lot and do not always vouch. A reason for the small size of this forum might be the high charges for the escrow service or, even more likely, the lack of a user-based reputation system. Only the administrator is able to assess other users, based on intransparent criteria. This might be too little to build trust among the users and to boost trade.

Bpcsquad and Altenen do not particularly diverge from the general findings. Bpcsquad is relatively small and the low number of ratings may denote unsuccessful deals. It is thus uncertain how strongly this forum will grow in future. Apropos growth, the enormous increase in members on Altenen is impressive. Apparently, it is attractive to be part of this large community. Numerous users means numerous and diverse products and a multitude of potential buyers, that is high supply and demand. As to the reputation systems, both platforms have reasonable and working basic solutions. Altenen provides an additional, arguably pseudo-protection measure.

To conclude this chapter, several limitations of this study should be mentioned:

- Firstly, the three-months-period does not allow long-term conclusions. After all, due to the applied technique of considering the vouchings of this time period, also older – and often very profitable – ads were included in the analysis.
- Secondly, the examination was carried out from a user's perspective. That is, no private messages could be investigated. In addition, VIP sections on the forums had to be ignored. The findings of this study do thus not give a complete picture of the forums. Nevertheless, substantial amounts of data could be gathered that allow some analyses and conclusions.
- A third limitation concerns the internal validity of the data. It cannot be excluded that other investigators, as for instance law enforcement, engage in trades on the forums for research and investigative purposes. This might impair the data. However, we do not assess this possibility as a substantial threat.
- Another threat to internal validity are the recorded product prices. The prices advertised are not necessarily the prices that are paid for. No post was found where the possibility of price negotiations was mentioned. Nevertheless, it cannot be excluded that users pay other, probably lower prices than those advertised.

- Finally, given that the examined forums trade different goods or attract certain types of users, the findings are an artefact of the forums in question and do not represent the entire carding underworld. The results are only valid for these five forums. The selection of the forums is thus a threat to external validity. This limitation concerns all hypotheses but especially **H<sub>6</sub>** where an explicit cross-forum comparison was executed. In principle, this limitation was overcome by selecting five different forums based on various selection criteria.

## 6 Conclusion

This study presented an overview of 25 existing online carding forums and an in-depth analysis of five of these forums, covering a three-month period of monitoring. What this study differentiates from others is, firstly, the investigation of real data instead of drawing conclusions solely based on literature or expert opinion, secondly, the examination of running instead of closed forums and thirdly, a low-level focus on products, prices and sellers.

We were able to show that almost half of the analysed threads are advertisements for CVVs. The other half are dumps, fullz and PayPal-credentials. The mean price for CVVs is \$10; dumps and fullz are traded for more than threefold. Prices vary depending on issuing country and precise product type. We further illustrated that the traffic generated on the forums is highly unevenly distributed among sellers, with a small group of users responsible for the majority of traffic. The hypothesis that traders are specialised was not confirmed. 38% meet this expectation. Regarding reputation and trust, all the forums have some kind of reputation system, in theory, but they are not as elaborated as eBay's. Nevertheless, a reliable reputation system seems to be an important basic requirement to facilitate trades. The analysis showed, finally, that users are generally not present on multiple forums. It was hypothesised that the effort needed for gaining trust on each forum might be the reason for that.

Overall, despite upcoming products like online account credentials, credit cards are still prominent in the underground economy. The prices are within the range given by the existing literature. Generally, as far as the results can be compared with those illustrated by the existing literature, the characteristics of running forums do not markedly diverge from those of forums that are shut down.

The findings also suggest that the market of carding forums is dynamic. New forums open, others close and existing ones partially record immense increases in members and postings. It is not clear, however, how promising the future of carding forums is. The emergence of single-vendor stores could mean that high-profile sellers will open their own stores. Numerous forum posts containing links to stores might indicate a shift of the business towards such stores. It is questionable how attractive forums still would be as trading platforms if these high-profile sellers had gone and only low-profile users remained.

Targeting these high-profile sellers is probably the most promising approach in reducing existing carding crimes. By reference to the number of vouchings, the study showed that these sellers are identifiable. They are more worth focusing on than users advertising a myriad of

products but, in fact, not selling anything or even being rippers. With respect to tackling forums, it seems audacious to focus on larger forums. Although also small ones are dominated by individual prosperous traders, they do not appear to generate this amount of traffic that these traders do on large forums.

A crucial subject for future research are the above-quoted stores. Is there really a shift from forums to shops and if yes, what are the consequences? Furthermore, who are the corresponding sellers? How much traffic do they generate? How can these stores be tackled? These are questions to be answered in future.

Whereas the sellers were in the centre of this study, future research should also consider their counterparts, the buyers. The reviewed literature did not cover buyers and they were also neglected in this paper. It might be useful to examine whether there are as well high-profile buyers and, in order to identify any patterns, to observe what they buy and whether and to whom they resell the products.

Regarding research design and methodology, a long-term or a follow-up study might be able to identify trends or to confirm the patterns found in this study, respectively. As far as the data collection method is concerned, future research could even go deeper. Precisely, researchers might engage in trades and get in touch with the traders. This method would allow to collect more information on the traders and to better understand their role within the fraud chain. These findings would help further improve the conditions for countering financial cybercrime in future.

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## Appendix

| <b>Forum name</b>   | <b>Forum address (http://...)</b> |
|---------------------|-----------------------------------|
| Agoraforum          | lacbzxobeprrsrfx.onion/           |
| <b>Altenen</b>      | www.altenen.com                   |
| Crdpro              | crdpro.su                         |
| <b>Crimenetwork</b> | crimenc5wxi63f4r.onion            |
| Cardingforum        | www.cardingforum.org              |
| Hackingforum        | hackingforum.ru                   |
| Unixorder           | www.unixorder.com                 |
| Crdclub             | crdclub.ws                        |
| Carderscave         | www.carderscave.ru                |
| Infraud             | infraud.cc                        |
| Lampeduza           | lampeduza.so                      |
| Blackstuff          | www.blackstuff.net/forum.php      |
| Bus1Nezz            | bus1nezz.biz                      |
| Cardingmafia        | www.cardingmafia.ws               |
| <b>Bpcsquad</b>     | www.bpcsquad.com                  |
| Procarder           | www.procarder.ru                  |
| Cardersforum        | www.cardersforum.se/              |
| Crimes              | crimes.ws/                        |
| Carderbase          | carderbase.su                     |
| Carder              | carder.me                         |
| Darkstuff           | www.darkstuff.net                 |
| Coinodeal           | coinodeal.com                     |
| <b>Tuxedocrew</b>   | www.tuxedocrew.biz                |
| Privatemarket       | privatemarket.us                  |
| Omerta              | omerta.cm                         |

Table A1: Forum names and web addresses

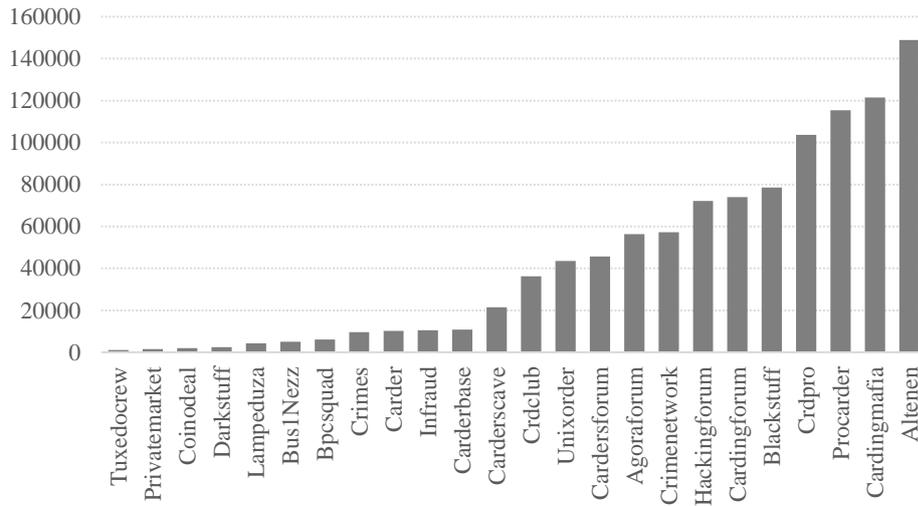


Figure A1: Number of members per forum

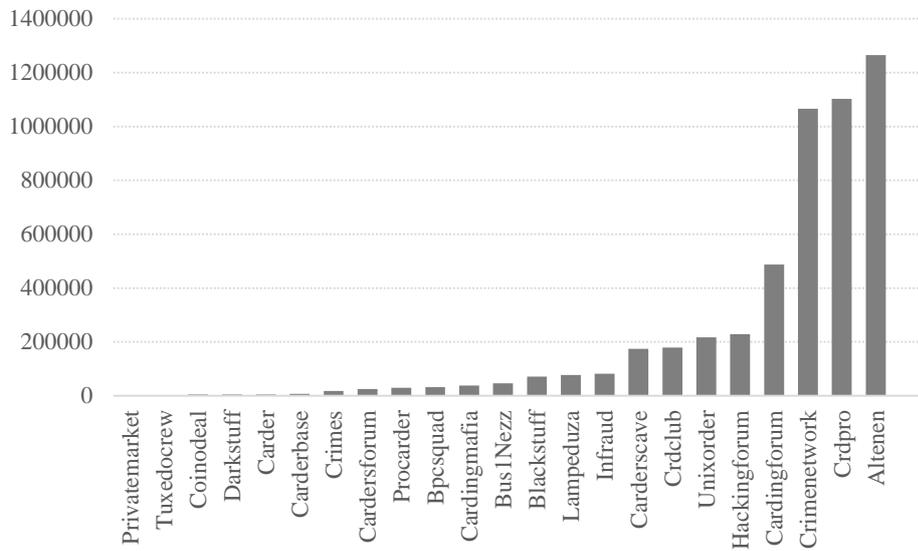


Figure A2: Number of posts per forum (Agoraforum excluded)

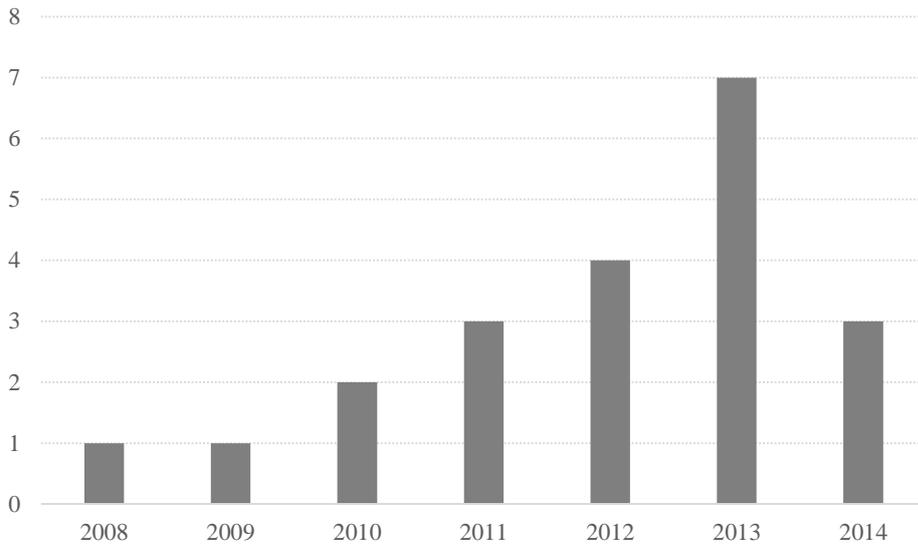


Figure A3: Number of forums per founding year