[[1]](#footnote-1)

Enlighten DarkWeb Markets with Data Mining

First A. Author, *Fellow, IEEE*, Second B. Author, and Third C. Author, Jr., Member, IEEE

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# INTRODUCTION

P

OLICE forces have been fighting strenuously against illegal websites (e.g. Megaupload [1]), but new ones resurface or re-migrate frequently [2]. This is also happening on the dark web. As a matter of fact, plenty of marketplaces have been shut down, however there are still a lot of them online at the time of this research [3]. On top of that, currently, we don't really know in detail how these websites operate.

This paper presents a research carried out between June and September 2017 on the largest web market at the time (especially for drugs) on Internet, AlphaBay. This web market has caught the attention of governmental agencies since two teenagers aged of 13 and 18 died after overdosing on a powerful synthetic opioid. It has been shut down on July 2017, at the same time of Hansa, as a part of a law enforcement operation by the Federal Bureau of Investigation, the Drugs Enforcement Administration and European law enforcement agencies acting through Europol. [4] [5]

According to US Attorney General Jeff Sessions the aim of this action was to caution criminals from thinking that they could evade prosecution by using the dark web. Looking at previous large shut down marketplaces it is widely believed that other web markets will take the place of AlphaBay. By the way, the popularity of AlphaBay can be explained by the shutdown of Silk Road 2.0 on 2013 since it has been launched on September 2014.

This paper reports on the last weeks of life of Alphabay. Its nature, its different countries of origin, its main sellers, its predominance of items will be analyzed.

# Method

[AB part].

During a first phase "Basic Statistics" will be carried out on the Database, in order to discover the web market and to point out its trends. Then, experimental results of data mining techniques will be discussed.

# Technical Implementation

## Software Stack

There is a number of technologies and programming languages that can be used for Data Analysis. The 3 main programming languages for this kind of research are Python, SAS and R. Since we would like to use open-source languages, we exclude SAS and eventually chose R. [6]

Beside standard libraries, we have made extensive use of:

### units: Unit library including solution for conversion.

### rpart: Package that contains a wide library for decision tree method.

### arules: Used for association rules.

### e1071: Bayesian Naive implementation library.

### bnlearn: Library including solution for Bayesian network creation and visualization.

We have used RStudio for implementing code. As for publishing the results, we have used R Notebooks [7].

## Code Repository

All the code is publicly available in the GitHub project "Data Mining - Dark Web Market". The repository is accessible from the following link: <https://github.com/SimonDele/Data-Ming-Dark-Web-Market>

You can also find the whole list of packages used in the GitHub repository.

## Detailed Diagram

This is the representation of the technical implementation taking place during this project:

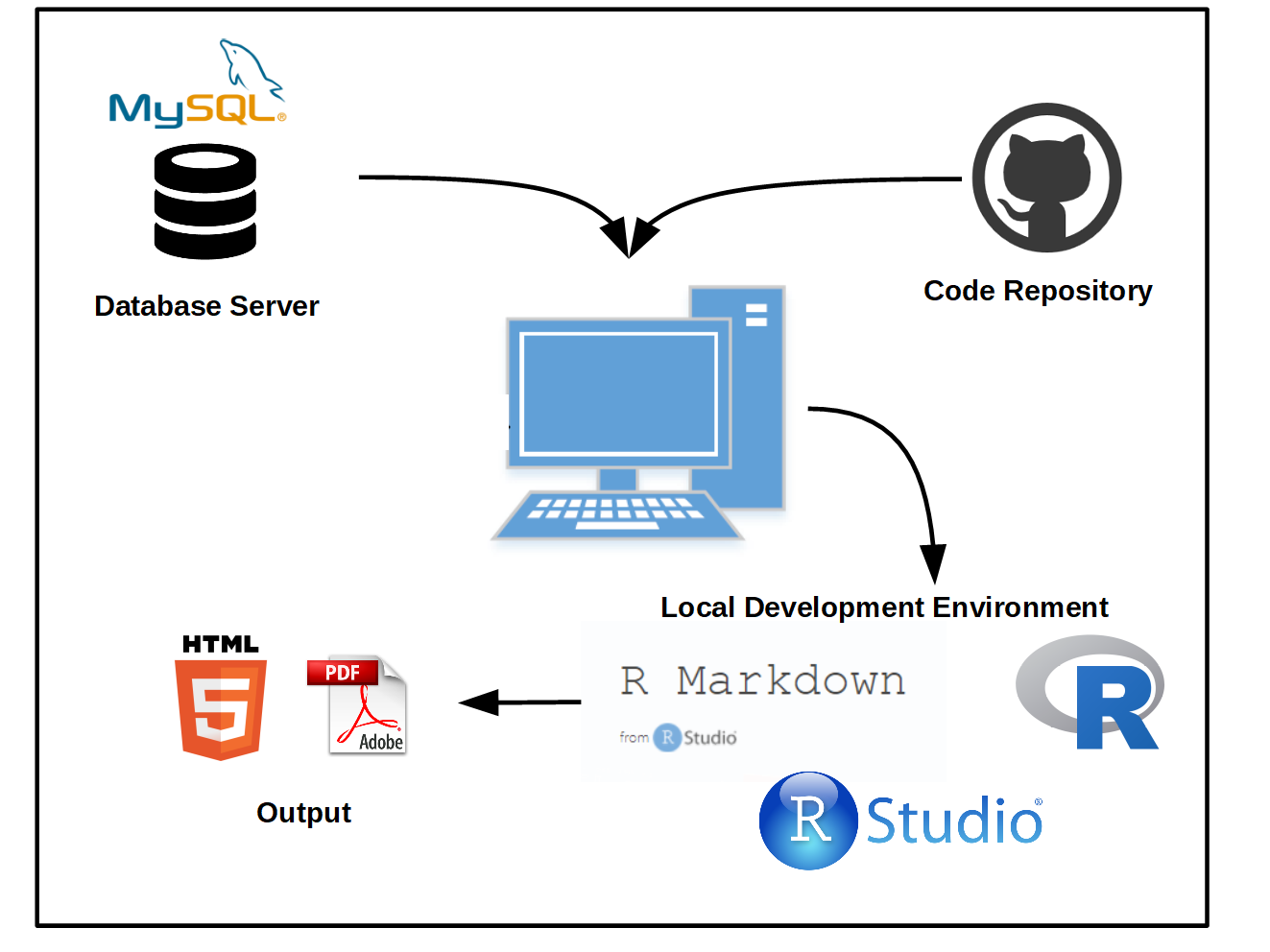


Fig. 1. Technical implementation

# Data Retrieval

For each product we have collected and analyzed ad title, description, price (in USD), URL, seller, payment, origin, destination, category, collection timestamp, date of posting and number of products sold.

[AB to refine] The data represents approximately \*1/10\* of the Web Market, but gives a pretty good representation since the uploaded ads were fairly distributed.

Thus, the first step was to clean the data and to make it readable in a computer way. This is our pipelines:

### Removing special characters, switching in lowercase.

### Finding in the title or description of the ads the amount (number and mass) of the product.

### Calculating the price of one unit of one dose (1 gram) each time.

# Alphabay Market

As it has been said in the INTRODUCTION, AlphaBay, due to its popularity, drew the police forces attentions. As a matter of fact its reputation can be reflected by looking at Google search statistics with the keywords Alphabay and dream market between January 2015 until June 2017. [8]

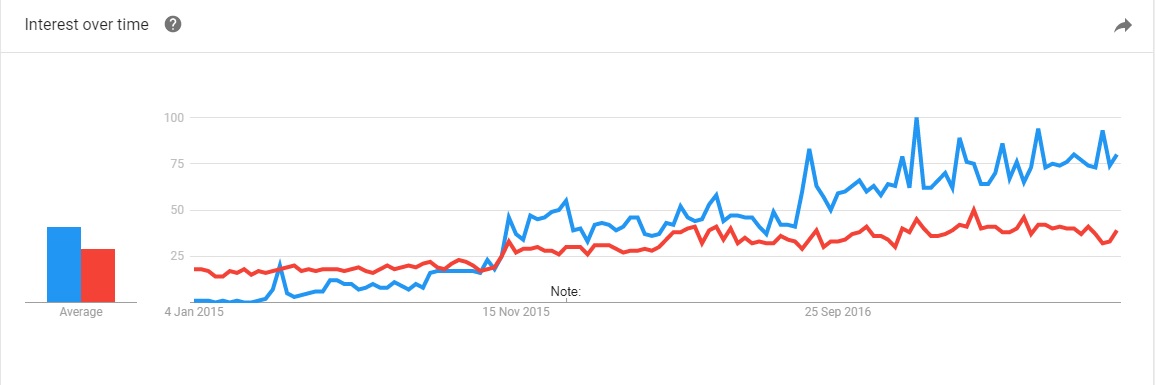


Fig. 2 Evolution of AlphaBay and Dream Market Google researches

On this graph, AlphaBay is in blue and Dream Market is in red, which is another Dark Web Market still operating. AlphaBay has become more and more popular since the demise of Agora, and before being shut down, it was the most popular dark web market [9]

Let's now try to look at the evolution of the market with the collected data on AlphaBay. Here you can see the number of ads posted per month from January 2015 until June 2017.

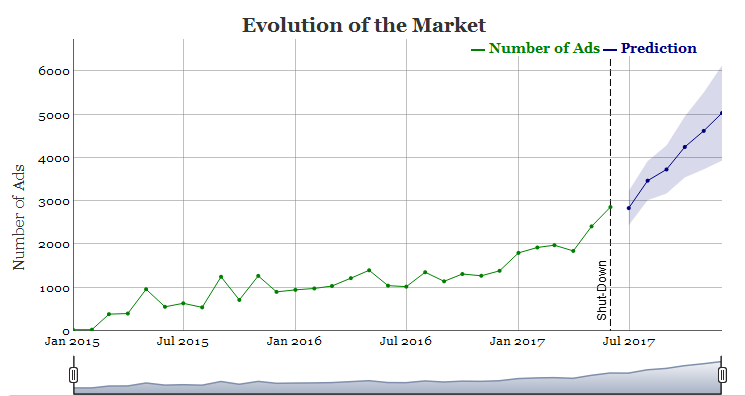


Fig. 3 Evolution f AlphaBay web market

The overall appearance and the growing popularity can be again pointed out with this graph. Between 2015 and 2016, there was a significant jump, the amount of ads rose from 7,712 up to14,161. Nevertheless the most surprising thing is that the number of ads that have been posted during the six first months of 2017 (before the closing) is 12,878 which is almost the same that in the whole 2016.

In order to see how the market would have looked like in the end of 2017 a prediction also has been added on this graph. Therefore, according to prognoses, the amount of ads would have reached a pick of 5,000 ads by the end of year.

# Basic Statistics

As it has been said before, basic statistics have been first realized. Let's see the general distribution and trend of the market.

## General Distribution

### Global view of ads distribution

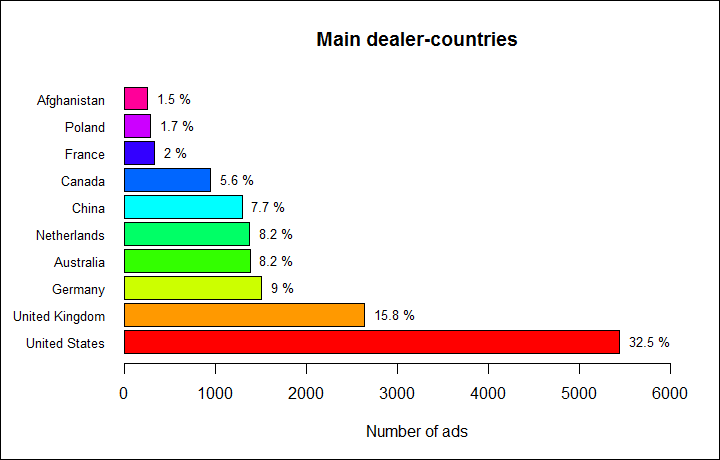


Fig. 4 Main dealer countries

This bar-chart represents the 10 main countries in the world regarding the number of ads. As we can see, United States are the biggest dealer far ahead of the rest. Their number of ads is more than twice as the number of the second one, United Kingdom.

Moreover, it is noticeable that most of these countries have strong economies. Five of the top 10 countries belong to the Group of Seven (G7), only Japan and Italy are not present. And other ones are also located in powerful areas where a lot of trade are made with other countries.

Furthermore it is worth pointing out that the first four countries are exactly the ones where the word "AlphaBay" is the most researched on Google [10] !

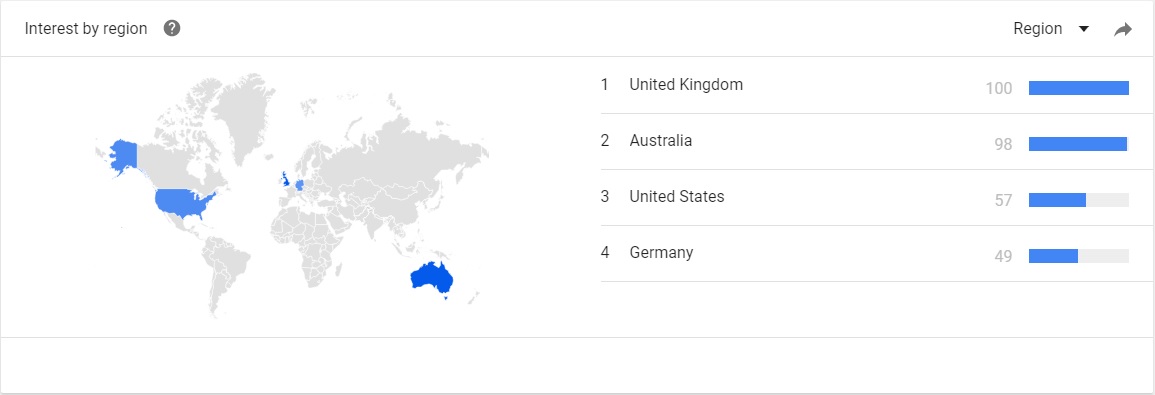


Fig. 5 AlphaBay world Google researches

### Distribution of ads per category

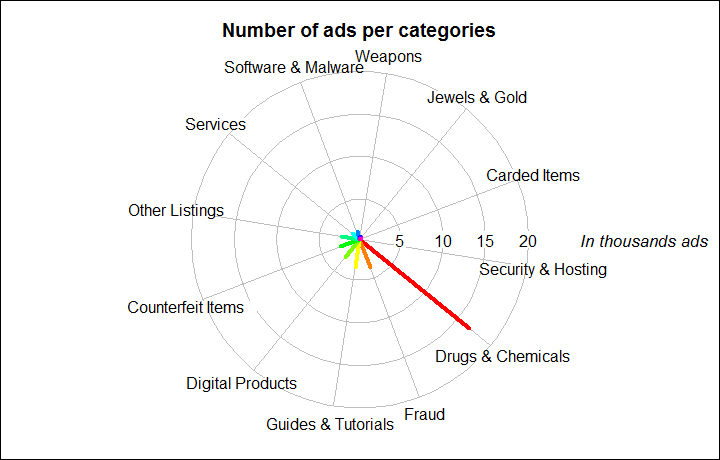


Fig. 6 Distribution of the market

There are 12 main categories in this web marketplace. "Drugs and Chemicals" group is the largest one, representing 45.64 % of the global market.

It is also worth noting that the second most popular category is "Fraud", that is to say all the ads regarding impersonation, deception papers and accounts. It represents 13.5 % of the market. Eventually, all other items (digital product, weapons, jewelry ...) represent a small rate of the marketplace.

## Drug Market

AlphaBay core focus is clearly on Drugs (cf. Fig. 6.).

### Distribution of drugs

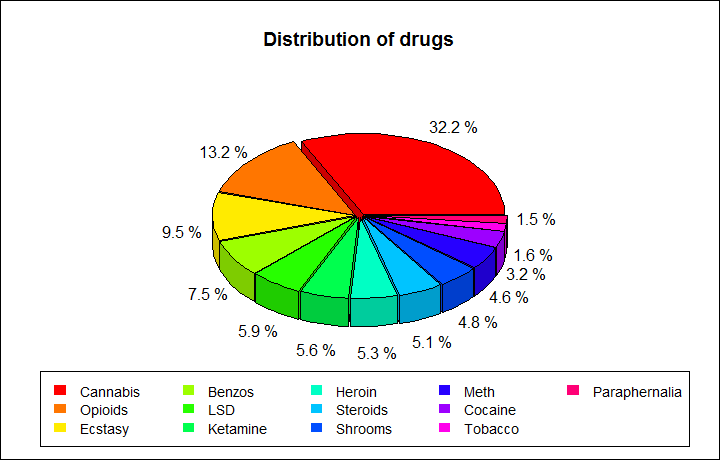


Fig. 7 Drug distribution

AlphaBay includes 13 subcategories for drugs. That said, Cannabis, Opioids and Ecstasy cover more than 50 % of the market.

### World distribution of drugs

When looking at drug-related ads by country, it is worth noting that the distribution of Figure 8 has a strong resemblance with the overall ad distribution by country on AlphaBay (Fig. 4). This is coherent, indeed, by comparing the ratio between drugs ads and the total number of ads, it is intelligible that they are mainly dealing drugs.

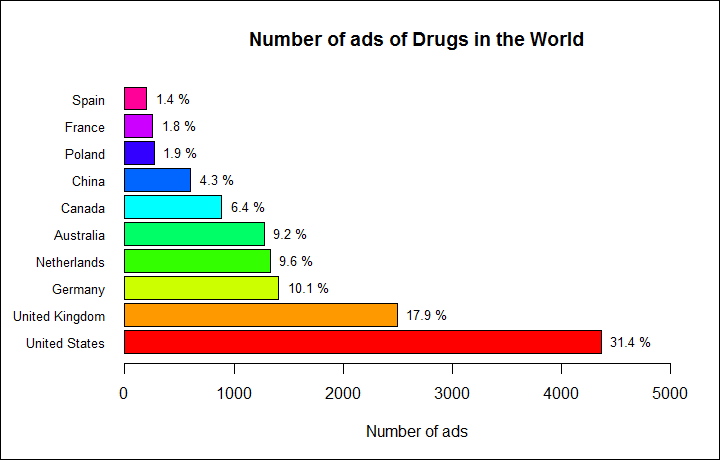


Fig. 8 Main drug dealer countries

So far it is possible to conclude that the market of drugs is gathered in Europe and the north of America.

### Global view of the drugs market in Europe

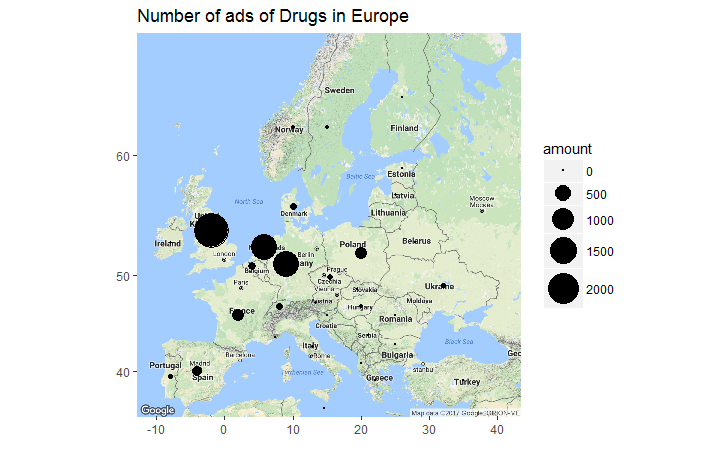


Fig. 9 European drug dealers

Circles show the amount of ads concerning drugs. The map confirms previous assumptions that the majority of the products is supposedly originating from United Kingdom, Netherlands and Germany.

It appears that dealer-countries are located on the Atlantic Coast and own huge harbours where there is important merchant shipping. Whereas on the East part there are not a lot of activities. This is probably due to the fact that dealers are using international commercial maritime traffics in order to dispatch their drugs all around the world. Maritime transport is an option increasingly used since it allows them to carry large quantities at one time. Drugs can be transported in small and fast boats (Go-Fast-Boat between countries border) or in containers on commercial vessels. Thus, significant seaports in Europe such as Rotterdam in Netherlands or Antwerp in Belgium are key points for this type of trafficking. In 2014 “Dutch police estimated that 25-50 % of the cocaine reaching Europe now enters via the port, which handles around 11 million containers a year.” [11]

## Product Flow By Country

Let’s now focus more specifically on different countries and study their trend. To do so, export and import flows of the country have been investigated.

### United Kingdom exportation

The chart below (Fig. 10) represents the repartition of each category that United Kingdom supposedly exports.

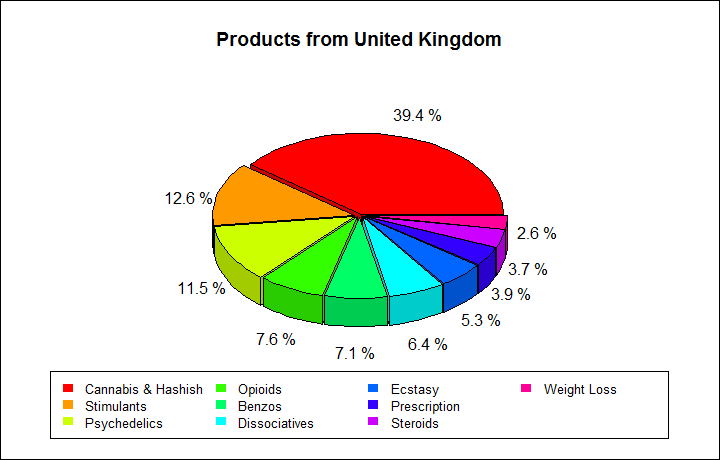


Fig. 10 Products from United Kingdom

Once again this chart shows the market diversity. Although a huge part concerns “Cannabis & Hashish” category, “Stimulants” and other illegal drugs are significantly present as well.

Most of European countries follows the same pattern as United Kingdom and this confirms previous assumptions.

### Products from Afghanistan

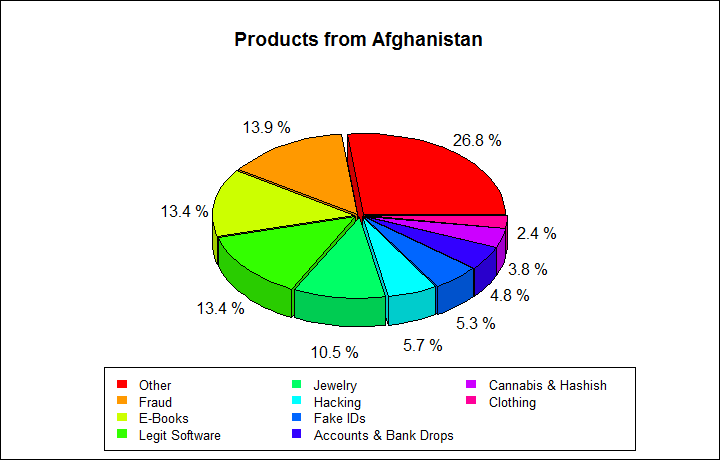


Fig. 11 Products from Afghanistan

It is interesting to notice that, unlike most of countries, Afghanistan doesn’t really retail drugs on AlphaBay market. Actually, a vast majority of exported products are false identity, deception accounts… Afghanistan is also dealing electronic devices or software.

### France export & import flows

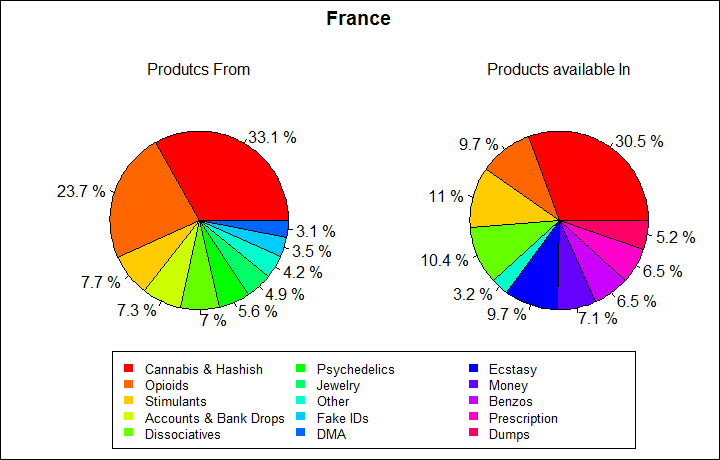


Fig. 12 Products from and available in France

It is noticeable that both charts are different. The percentages of each category are not equal and some of them don’t appear systematically in the other chart.

Nevertheless these conclusions should be moderated since targeting one particular country reduces significantly the number of information used for statistics.

## Market Prices

After analyzing general trend and flows, one interesting topic to analyze is market prices. One may ask if sold products in AlphaBay are cheaper than in the streets.

### Average prices

Firstly, the median price of one gram of the most common drugs has been calculated and results below has been obtained.

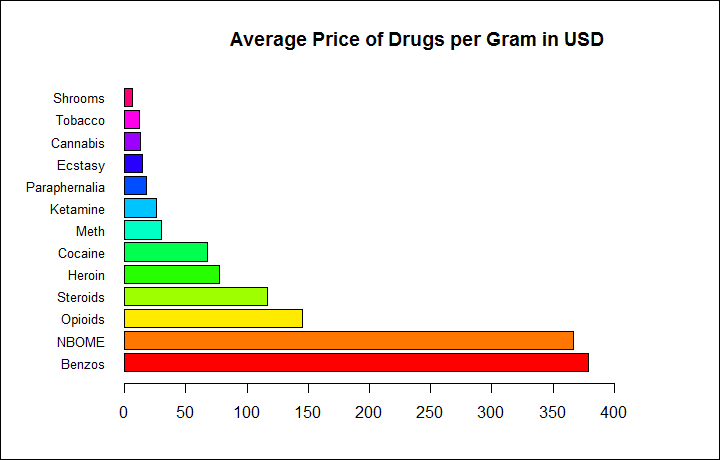


Fig. 13 AlphaBay drug prices

### Comparison with the “street”

Information on street prices for commonly available drugs have been collected on websites.

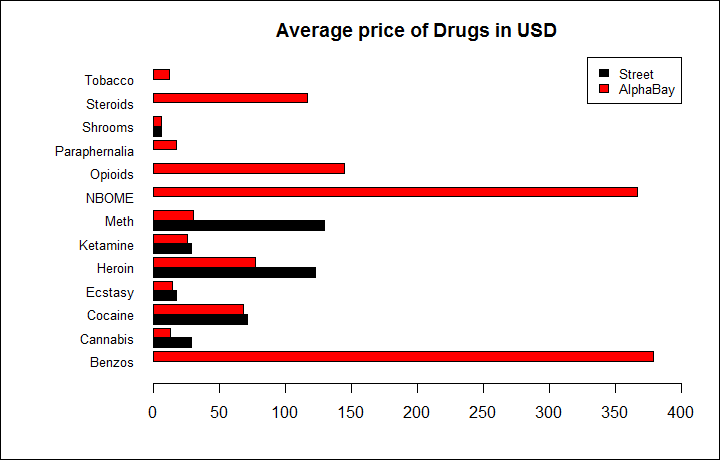


Fig. 14 Comparison of Prices between AlphaBay and Street

`Globally, it appears that prices of street sellers are often largely higher than AlphaBay ads. In few cases both prices tend to be similar. (Please find in the last section all references used: [12] [13] [14] [15] [16])

# Drugs on AlphaBay - Exploration analysis

Secondly, data mining techniques have been performed in order to discover hidden rules and correlations in the database.

## Sellers Predictions

The first thing to wonder is how to guess the seller of an ad. This knowledge could enable to identify sellers in other web market. To answer this question, different data mining methods have been used, especially Decision Tree and Bayesian classification.

Algorithm has been run on a subset of the database with by rows ads and by columns the origin, category, seller and price. The aim is to predict who is selling each ads. By training the algorithm on one half of the data, predictions could be made on other half. Given that most of sellers own just few ads (occasional advertisements) only the main ones were selected, which represent at best the market. Otherwise, data mining techniques will fail in finding rules for them.

To check efficiency of the algorithm a measure of accuracy must be calculated. It is obtain by comparing the prediction of decision tree method with the true value.

### Decision tree

Using rpart package, which is based on the CART Algorithm, a decision tree has been created. Thanks to it, predictions of the seller could be made. Prognoses on the five most significant sellers and the related tree can be found below.

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# References

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| --- | --- |
| [1] | "Megaupload file-sharing Site Shut Down," BBC News, 08 03 2012. [Online]. Available: http://www.bbc.co.uk/news/technology-16642369. [Accessed 07 08 2017]. |
| [2] | Reuters, "Megaupload Reboot ? Founder kim dotcom plans a relaunch in 2017," The guardian, 11 07 2016. [Online]. Available: https://www.theguardian.com/technology/2016/jul/11/kim-dotcom-megaupload-founder-plans-reboot-2017. [Accessed 07 08 2017]. |
| [3] | "Dark Web & Deep Web market list with up & down daily updated market status," DarkWebNews, [Online]. Available: https://darkwebnews.com/dark-web-market-list/. [Accessed 07 08 2017]. |
| [4] | C. Baraniuk, "Alphabay and Hansa Dark Web Markets shut down," BBC news, 20 07 2017. [Online]. Available: http://www.bbc.co.uk/news/technology-40670010. [Accessed 24 07 2017]. |
| [5] | T. Kopan, "Doj announces takedown of dark web market Alphabay," CNN, 07 20 2017. [Online]. Available: http://edition.cnn.com/2017/07/20/politics/doj-takes-down-dark-web-marketplace-alphabay/index.html. [Accessed 24 07 2017]. |
| [6] | "2017 SAS, R, or Python flash survey results," Burtch works, 19 06 2017. [Online]. Available: http://www.burtchworks.com/2017/06/19/2017-sas-r-python-flash-survey-results/. [Accessed 08 07 2017]. |
| [7] | "R Markdown tutorial," R Markdown from RStudio, [Online]. Available: http://rmarkdown.rstudio.com/lesson-1.html. [Accessed 29 06 2017]. |
| [8] | "Explore: AlphaBay, Dream Market," Google trends, [Online]. Available: https://trends.google.co.uk/trends/explore?date=2015-01-01%202017-07-01&q=alphabay,Dream%20Market. [Accessed 22 07 2017]. |
| [9] | "Forget silk road, cops just scored their biggest victory against the dark web drug trade," Forbes, 20 07 2017. [Online]. Available: https://www.forbes.com/sites/thomasbrewster/2017/07/20/alphabay-hansa-dark-web-markets-taken-down-in-massive-drug-bust-operation/#480a3cb05b4b. [Accessed 07 08 2017]. |
| [10] | "Explore: AlphaBay," Google trends, [Online]. Available: https://trends.google.co.uk/trends/explore?date=2014-12-01%202017-07-01&q=alphabay. [Accessed 22 07 2017]. |
| [11] | "Cocaine – Trafficking and supply," EU drug markets report, [Online]. Available: http://www.emcdda.europa.eu/publications/eu-drug-markets/2016/online/cocaine/trafficking-and-supply. [Accessed 24 07 2017]. |
| [12] | "How much do drugs cost?," DrugWise, [Online]. Available: http://www.drugwise.org.uk/how-much-do-drugs-cost/. [Accessed 12 07 2017]. |
| [13] | "The cost of street drugs in britain," The Telegraph, [Online]. Available: http://www.telegraph.co.uk/news/uknews/crime/11346133/The-cost-of-street-drugs-in-Britain.html. [Accessed 12 07 2017]. |
| [14] | "The average cost of illegal street drugs," RehabCenters.net, [Online]. Available: http://www.rehabcenter.net/the-average-cost-of-illegal-drugs-on-the-street/. [Accessed 12 07 2017]. |
| [15] | "What illegal drugs cost on the street around the world," Canada.com, [Online]. Available: http://o.canada.com/business/interactive-what-illegal-drugs-cost-on-the-street-around-the-world. [Accessed 12 07 2017]. |
| [16] | "Facts about drugs," The student pocket guide, [Online]. Available: http://www.thestudentpocketguide.com/2012/01/student-life/health-and-relationships/facts-about-drugs/. [Accessed 12 07 2017]. |

*Basic format for books:*

J. K. Author, “Title of chapter in the book,” in *Title of His Published Book, x*th ed. City of Publisher, (only U.S. State), Country: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

*Examples:*

1. G. O. Young, “Synthetic structure of industrial plastics,” in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15–64.
2. W.-K. Chen, *Linear Networks and Systems.* Belmont, CA, USA: Wadsworth, 1993, pp. 123–135.

*Basic format for periodicals:*

J. K. Author, “Name of paper,” *Abbrev. Title of Periodical*, vol. *x, no*. *x,* pp*. xxx-xxx,* Abbrev. Month, year, DOI. 10.1109.*XXX*.123456.

*Examples:*

1. J. U. Duncombe, “Infrared navigation—Part I: An assessment of feasibility,” *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959, 10.1109/TED.2016.2628402.
2. E. P. Wigner, “Theory of traveling-wave optical laser,”   
   *Phys. Rev*.,   
   vol. 134, pp. A635–A646, Dec. 1965.
3. E. H. Miller, “A note on reflector arrays,” *IEEE Trans. Antennas Propagat*., to be published.

*Basic format for reports:*

J. K. Author, “Title of report,” Abbrev. Name of Co., City of Co., Abbrev. State, Country, Rep. *xxx*, year.

*Examples:*

1. E. E. Reber, R. L. Michell, and C. J. Carter, “Oxygen absorption in the earth’s atmosphere,” Aerospace Corp., Los Angeles, CA, USA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
2. J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, TX, USA, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

*Basic format for handbooks:*

*Name of Manual/Handbook, x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, Country, year, pp. *xxx-xxx.*

*Examples:*

1. *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, USA, 1985, pp. 44–60.
2. *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, USA, 1989.

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*Examples:*

1. G. O. Young, “Synthetic structure of industrial plastics,” in Plastics, vol. 3, Polymers of Hexadromicon, J. Peters, Ed., 2nd ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15-64. [Online]. Available: http://www.bookref.com.
2. *The Founders’ Constitution*, Philip B. Kurland and Ralph Lerner, eds., Chicago, IL, USA: Univ. Chicago Press, 1987. [Online]. Available: http://press-pubs.uchicago.edu/founders/
3. The Terahertz Wave eBook. ZOmega Terahertz Corp., 2014. [Online]. Available: http://dl.z-thz.com/eBook/zomega\_ebook\_pdf\_1206\_sr.pdf. Accessed on: May 19, 2014.
4. Philip B. Kurland and Ralph Lerner, eds., *The Founders’ Constitution.* Chicago, IL, USA: Univ. of Chicago Press, 1987, Accessed on: Feb. 28, 2010, [Online] Available: http://press-pubs.uchicago.edu/founders/

*Basic format for journals (when available online):*

J. K. Author, “Name of paper,” *Abbrev. Title of Periodical*, vol. *x*, no. *x*, pp. *xxx-xxx*, Abbrev. Month, year. Accessed on: Month, Day, year, DOI: 10.1109.*XXX*.123456, [Online].

*Examples:*

1. J. S. Turner, “New directions in communications,” *IEEE J. Sel. Areas Commun*., vol. 13, no. 1, pp. 11-23, Jan. 1995.
2. W. P. Risk, G. S. Kino, and H. J. Shaw, “Fiber-optic frequency shifter using a surface acoustic wave incident at an oblique angle,” *Opt. Lett.*, vol. 11, no. 2, pp. 115–117, Feb. 1986.
3. P. Kopyt *et al., “*Electric properties of graphene-based conductive layers from DC up to terahertz range,” *IEEE THz Sci. Technol.,* to be published. DOI: 10.1109/TTHZ.2016.2544142.

*Basic format for papers presented at conferences (when available online):*

J.K. Author. (year, month). Title. presented at abbrev. conference title. [Type of Medium]. Available: site/path/file

*Example:*

1. PROCESS Corporation, Boston, MA, USA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at INET96 Annual Meeting. [Online]. Available: http://home.process.com/Intranets/wp2.htp

*Basic format for reports and handbooks (when available online):*

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*Examples:*

1. R. J. Hijmans and J. van Etten, “Raster: Geographic analysis and modeling with raster data,” R Package Version 2.0-12, Jan. 12, 2012. [Online]. Available: http://CRAN.R-project.org/package=raster
2. Teralyzer. Lytera UG, Kirchhain, Germany [Online]. Available: http://www.lytera.de/Terahertz\_THz\_Spectroscopy.php?id=home, Accessed on: Jun. 5, 2014

*Basic format for computer programs and electronic documents (when available online):*

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*Example:*

1. U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action*. [Online]. Available: LEXIS Library: GENFED File: BILLS

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Name of the invention, by inventor’s name. (year, month day). Patent Number[Type of medium]. Available: site/path/file

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1. Musical toothbrush with mirror, by L.M.R. Brooks. (1992, May 19). Patent D 326 189

[Online]. Available: NEXIS Library: LEXPAT File: DES

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J. K. Author, “Title of paper,” in *Abbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), Country, year, pp. *xxxxxx.*

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1. D. B. Payne and J. R. Stern, “Wavelength-switched pas- sively coupled single-mode optical network,” in *Proc. IOOC-ECOC,* Boston, MA, USA,1985,   
   pp. 585–590.

*Example for papers presented at conferences (unpublished):*

1. D. Ebehard and E. Voges, “Digital single sideband detection for interferometric sensors,” presented at the *2nd Int. Conf. Optical Fiber Sensors,* Stuttgart, Germany, Jan. 2-5, 1984.

*Basic format for patents:*

J. K. Author, “Title of patent,” U.S. Patent *x xxx xxx*, Abbrev. Month, day, year.

*Example:*

1. G. Brandli and M. Dick, “Alternating current fed power supply,” U.S. Patent 4 084 217, Nov. 4, 1978.

*Basic format**for theses (M.S.) and dissertations (Ph.D.):*

a) J. K. Author, “Title of thesis,” M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

b) J. K. Author, “Title of dissertation,” Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

*Examples:*

1. J. O. Williams, “Narrow-band analyzer,” Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, USA, 1993.
2. N. Kawasaki, “Parametric study of thermal and chemical nonequilibrium nozzle flow,” M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

*Basic format for the most common types of unpublished references:*

a) J. K. Author, private communication, Abbrev. Month, year.

b) J. K. Author, “Title of paper,” unpublished.

c) J. K. Author, “Title of paper,” to be published.

*Examples:*

1. A. Harrison, private communication, May 1995.
2. B. Smith, “An approach to graphs of linear forms,” unpublished.
3. A. Brahms, “Representation error for real numbers in binary computer arithmetic,” IEEE Computer Group Repository, Paper R-67-85.

*Basic formats for standards:*

a) *Title of Standard*, Standard number, date.

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*Examples:*

1. IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.
2. Letter Symbols for Quantities, ANSI Standard Y10.5-1968.

*Article number in reference examples:*

1. R. Fardel, M. Nagel, F. Nuesch, T. Lippert, and A. Wokaun, “Fabrication of organic light emitting diode pixels by laser-assisted forward transfer,” *Appl. Phys. Lett.*, vol. 91, no. 6, Aug. 2007, Art. no. 061103.
2. J. Zhang and N. Tansu, “Optical gain and laser characteristics of InGaN quantum wells on ternary InGaN substrates,” *IEEE Photon. J.*, vol. 5, no. 2, Apr. 2013, Art. no. 2600111

*Example when using et al.:*

1. S. Azodolmolky *et al.*, Experimental demonstration of an impairment aware network planning and operation tool for transparent/translucent optical networks,” *J. Lightw. Technol.*, vol. 29, no. 4, pp. 439–448, Sep. 2011.

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Dr. Author was a recipient of the International Association of Geomagnetism and Aeronomy Young Scientist Award for Excellence in 2008, and the IEEE Electromagnetic Compatibility Society Best Symposium Paper Award in 2011.

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Mr. Author’s awards and honors include the Frew Fellowship (Australian Academy of Science), the I. I. Rabi Prize (APS), the European Frequency and Time Forum Award, the Carl Zeiss Research Award, the William F. Meggers Award and the Adolph Lomb Medal (OSA).

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