# Economics - Actors and Security Strategies

Michiel Doesburg
TU Delft
m.s.doesburg@student.tudelft.nl

Cas Buijs
TU Delft
s.j.m.buijs@student.tudelft.nl

Aleksandra Taneva
TU Delft
a.p.taneva@student.tudelft.nl

Elena Tsvetkova
TU Delft
e.o.tsvetkova@student.tudelft.nl

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**Abstract**

For the course Economics of Cybersecurity of the Master program Computer Science at Delft University of Technology, the security issue concerning the existence of underground marketplaces is evaluated, by analyzing the different actors and factors which influence it. An actor analysis is conducted including the problem owner, which was previously identified as the market owners of the underground markets, the law-enforcement agencies and the law makers. The countermeasures these actors could take in order to mitigate the security issue are discussed, along with the costs, benefits and the incentives for these measures. Then, the redefined security metric is analyzed with respect to the various factors that influence its variability.

# 1 Actor Analysis

The previous assignment explained the security issue, which is that law-enforcement agencies threaten the existence of underground markets. In this section three actors, identified in the previous assignment, are analyzed on the countermeasures they can take, the costs and benefits of deploying these countermeasures, whether the actors have incentives to use these countermeasure and what role externalities play regarding the security issue. In the previous assignment multiple actors were identified, of which some are, apart from the market owners who are the problem owner, law-enforcement agencies and law makers. These three actors are further used for the analysis.

## 1.1 Countermeasures

### 1.1.1 Law Makers

Law makers can influence the security issue by creating or changing laws that (in)directly affect it. One way to mitigate the security issue, which from the perspective of the law makers is the existence of the underground markets, is to make it less attractive for people to participate in this underground trade. The law makers can change the current legislative framework to include heavier punishments for laws that are violated. This includes high(er) fines but also jail time to discourage people of participation. If people no longer participate in the underground trade, this would lead to the underground markets ceasing to exist as they fulfill no function anymore.

### 1.1.2 Law-Enforcement Agencies

A problem for law-enforcement agencies is that underground markets operate on an international level, instead of a local level. When investigating a market or its users they are hindered by the boundaries of the territory they are allowed to operate in. Countermeasures to mitigate the security issue could be ones that directly influence it but also ones that support other countermeasures and make them more workable. The countermeasure that law-enforcement agencies could take is the founding of a collaboration on international level regarding tracking flows of goods, sharing information concerning suspicious packages and providing information to each other upon request about people when there is a well-found suspicion that they participate in the underground trade. As part of this countermeasure can be new scanners for the packages, an established group between the organisations that coordinate the collaboration and deal with the requests being made to each other, and adding an additional task for the legal departments for assessing whether requests for information are legitimate.

### 1.1.3 Market owners

In the previous assignment was discussed that the best strategy for the market owners, who are the problem owner, is to reduce the risk for the market in general. There are multiple measures market owners could take and one concrete countermeasure to mitigate the security issue is to increase the difficulty for law-enforcement agencies to infiltrate the market. This can be done by introducing better account management on the markets themselves. This countermeasure could be implemented by introducing strict referral systems, stringent entry requirements and the use of a reputation system for users, in order to make it harder for law-enforcement agencies to get access to the market. Also automatic removal of accounts that have not been used for a certain pre-defined period of time and those with a bad reputation as well as those that seem to behave suspiciously on the market as an advanced option.

## 1.2 Cost-Benefit Distribution

The cost-benefit overview is presented from the perspective of the market owner and on the other hand law enforcement agencies and law makers on the other. We identify the cost and benefits of the aforementioned countermeasures and the combination of these procedures on the society. The summarized cost-benefit distribution is presented in Table 1:

| | Market Owners | Law Makers | Law Enforcement Agencies |
|---|---|---|---|
| Costs | Minimal to upgrade and update algorithms for accepting new members;<br>Man-hours to implement this software | Man-hours for research;<br>Man-hours to actualize the current legislative framework | Man-hours to train people to use the new scanners;<br>Investment in new scanners;<br>Manpower due to increased demand of scanning more packages |
| Benefits | Less possibility to accept malicious members;<br>Members will feel more secure;<br>Possible revenue increase | Reducing chance of people being involved in illegal activity on the underground market | Strict control on suspicious packages;<br>Control over the supply chain of the market |

Table 1: Cost Benefit Distribution

## 1.3 Incentives

Incentives give us insight and detailed reasoning of why a certain strategy is being chosen over another one. For every actor observed in the previous section, we analyse the incentives that support or explain the chosen countermeasures.

- The motivation behind the law makers strategy is quite straightfoward to analyze. More severe measures will prevent people of being involved in the exchange and not being prosecuted. The law maker should have the strongest motivation to take the discussed countermeasure. By creating a better technical and legislative regulation, the illegal drug usage will drop, markets will lose its customers and probably even be shut down.

- Further, the law enforcement approach to imply technical control on the delivered packages will imply better control and that will affect indirectly the markets through lowering the successful rate of the selling and therefore lowering the reputation of sellers and the market itself.

- From a financial point of view, behind the motivation of the market owners is to protect both buyers and sellers, so the market owner does not . By increasing security and simultaneously increasing the trust and therefore the reputation of the market, he can increase his profit. However, there are direct cost that are required in order the market owner to mitigate the risk and increase the security of the users. They have the largest stake at hand because if they don't manage to mitigate the security risk, they will possibly lose sellers and buyers and consequently, shut down the market.

## 1.4 Role of externalities for the security issue

In consideration of the aforementioned actors, the externalities are supposed to be discussed from two different points of view. By definition, we can consider the externalities as providing simultaneously positive impact (as benefits) and negative impact (as costs) to different members of the society or different actors in terms of the security issue. Accordingly, the following externalities should be summarized in the report:

- By using stronger membership policy it will be harder for law enforcement agents to infiltrate the illegal markets. This means that there will be less possibility of discovering the identity and thus arresting sellers, which is beneficial for markets and the chances of being targeted by an agent are decreased. Therefore, this indirectly also positively affects a market since it is less possible the market to be attacked.

- By implementing control on the packages, the law enforcement agent will reduce the drug and gun abuse, but on the other hand that will bring losses to the seller and buyer. On the other hand, this will have a overall positive effect on the society.

# 2 Security performance differences

This section discusses the security performance metric that was chosen for further use in the assignment Different factors are discussed that can have an influence on the security performance of the actor and could explain the differences. In the end, an analysis is given of one factor to explore its impact on the security metric.

## 2.1 Security Performance Metric

In the previous assignment our metric seemed to be covering more than was our focus on. For this reason we use a different, more focused, metric for showing the security performance differences. Our metric is the cumulative lifespan of the top 20% most successful vendors in days per market per year. Successful vendors are those that make the most revenue on the market, the top 20% refers thus to the top 20% making the most revenue. The main assumption behind this metric is that successful vendors are drawn to secure markets. The more secure a market is, the more successful vendors will stay around for a long time. This assumption makes sense as vendors do not want to leave a market on which they make lots of money, unless there is a serious risk for the vendor i.e. a security issue. Thus, if a market is more secure, the successful vendors stay longer than in a market which is less secure. This would be visible by a higher cumulative lifespan in days for that market.

Looking at Figure 1 the first thing that can be noted is that after 2016, as a result of a large event, a downfall of all markets in our dataset happened. As this happened to all markets, the data after 2016 cannot be used for our analysis concerning the security performance differences. The focus will thus be on the time between 2011 and 2016.

When looking again at the figure, the cumulative lifespan lies between 10.000 days and 80.000 days, which is quiet a difference but can be explained by the different number of vendors per market. ‘Alphabay‘ seems to have the best security performance as they have the largest cumulative lifespan of their top 20% vendors. It also seems to have an increasing cumulative lifespan between 2015 and 2016, while other market’s numbers are going down in that period. This could mean that the market outperformed the others from a security perspective. Instead, ‘Hydra‘ seems to perform worst as the total lifespan of their vendors is less than 2.000 days in comparison. There are different factors that influence the lifespan of the vendors, which could explain these differences between the markets. Those factors are discussed in the next section.

## 2.2 Factors

The differences in security performance, as can be seen in Figure 1 could be explained by several factors that influence the metric. Not all of those factors

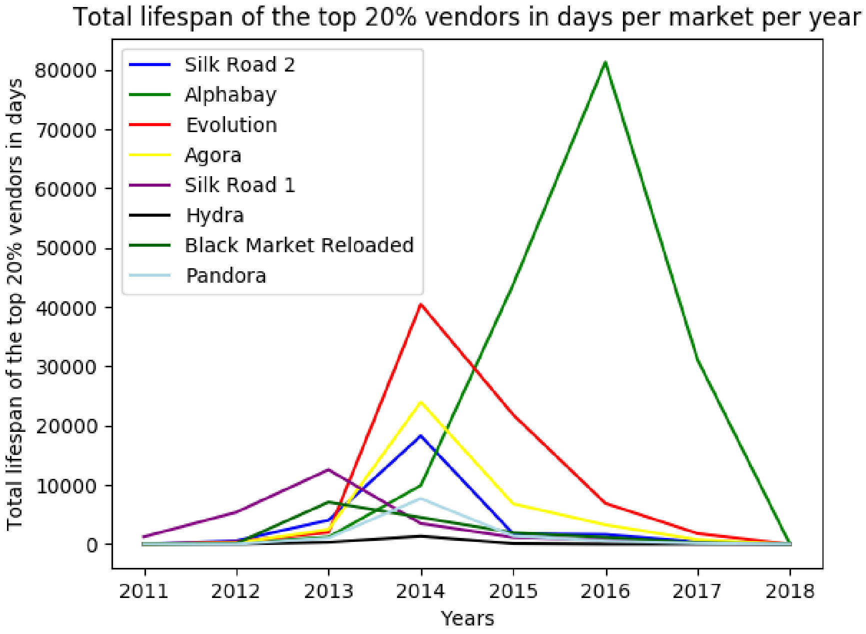


Figure 1: Cumulative lifespan of the top 20% most successful vendors in days per market per year

are necessarily related to security but still affect the security performance. This section discusses some factors of which we believe they affect the average lifespan of the successful vendors on a market. The section also states which factor is used for further statistical analysis.

### 2.2.1 Transaction fees

A factor that can influence the cumulative lifespan of a market's successful vendors is the transaction fee the market charges for each transaction. Transaction fees mean that the vendor earns less per sale or the buyers can be less inclined to buy something it they have to pay the fee. The more the market owner earns, the more it has to spend on improving the security of the platform that keeps successful vendors on its market and attracts new ones.

### 2.2.2 Reputation

The reputation of a market is also a factor that affects the cumulative lifespan of the market's successful vendors. Vendors are more likely to leave markets that have a bad reputation. There are many (smaller) factors that influence the reputation of a market, like the security of a market but also the prices of goods on the market. As this factor is very general it is hard to define it and find data about markets' reputations.

### 2.2.3 Payment service

What also influences the security performance of markets are the payment services that it offers. There are different kinds of online payment system, like: credit cards, PayPal, cryptocurrencies and action codes. The payment services differ in their traceability, which is easier for credit cards or PayPal than for cryptocurrencies and action codes. Although, even users of bitcoin (a pseudononymous payment system where users are only represented by an address number and not by name), has seen cases where vendors have been linked to their bitcoin address and were exposed. Thus the payment services offered by the market can improve or weaken the security of a market and affecting the cumulative lifespan of successful vendors.

### 2.2.4 Type of goods sold

Also the type of goods sold on a market are a factor affecting the security of the vendors and thus their lifespan on the market. Some type of goods, like cash-outs, have a direct affect as in that money is being taken by the buyers using the cash-out product. These type of goods thus might gain more attention from law-enforcement agencies as it directly takes money away from companies. This compared with other goods, like exploits, which might be used as part of malware and not have such a direct influence to gain priority. Selling particular type of goods thus influence the lifespan of the vendors and affect the security of the market (if a market sells more 'priority gaining' goods, it might get more attention from law-enforcement agencies).

### 2.2.5 Availability of escrow service or other scam countermeasures

The last factor to discuss is the availability of escrow services (or other scam countermeasures). An escrow service allows the money in a transaction from party A to party B to be temporarily stored at a third party. This third party, upon receival of the goods by party A, release the money and transfer it to party B. This prevents scams in which party B does not send the goods and walks away with the money. Markets offering these types of services have less issues with scams of this type and become more attractive to a non-scammer clientele. There exists some overlap with the reputation factor, as the availability of these kind of services improves the reputation of the market but it is also worth to be a factor by itself. By having such services available, it is more difficult for law-enforcement agencies to perform these kind of 'scams' to gain information on the buyers without actually sending what was offered. In turn this makes the market more attractive for buyers and more buyers attract more vendors that stay for a longer period of time. Thus improving the market for the successful vendors and thus the security of the market in terms of its existence.

## 2.3 Impact

In the previous section different factors have been identified that influence the security performance metric and thus could explain the variance between the different performances for the markets. As there is not much public information available regarding underground markets, we chose to only analyse the impact of the factor 'Type of goods sold' on the cumulative lifespan of the top 20% vendors for each market.

### Pearson Correlation

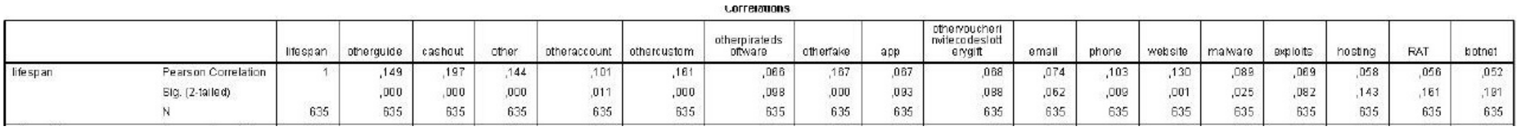
The pearson correlation is a way to measure the association between linearly related variables(*Correlation (Pearson, Kendall, Spearman)*, n.d.). The result of the correlation is a value in the interval between (and including) +1 and -1 with the sign indicating the kind of relationship. As there are different values the association can get and it is not a binary answer, different interpretations could be made using the data. We use Cohen's standard(*Correlation (Pearson, Kendall, Spearman)*, n.d.) to interpret the data, which means that when the value of coefficients falls between ‖0.10 - 0.29‖ it is seen as a small association, between ‖0.30 - 0.49‖ as a medium association and above ‖0.5‖ as a large association. Of course, there might be many things influencing the factors but using the pearson correlation it is, at least, possible to say something about those variables that show to have a small association.

The pearson correlation was calculated for each market per year, for each category of goods sold, the results can be found in table 2. The categories are respectively the following: other - guide, cash-out, other, other - account, other - custom, other - pirated software, other - fake, app, other - voucher/invite/codes/lottery/gift, e-mail, phone, website, malware, exploits, hosting, RAT and botnet.

When looking at the information in the table it becomes clear that in the beginning there are categories with a large association for markets but the further it gets in time, the smaller the association gets. This could be explained as a result of a new market being founded and thus attracting new vendors, at the start, which give rise to such a correlation. When the set of vendors has been established, the association seems to disappear or fall within the category of 'small' association.

### Linear Regression

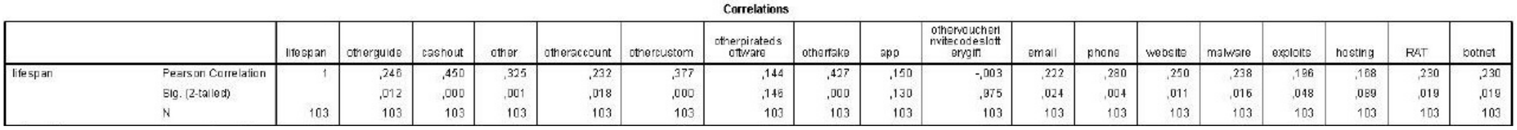
We used multiple linear regression to look at the effects of our different categories (predictors) on the lifespan per market. To do this we used SPSS, by first outputting the data to .csv files and then to .sav. At which point we ran the multiple linear regression analysis.



Correlations

| | | lifespan | otherguide | cashout | other | otheraccount | othercustom | otherpirateds oftware | otherfake | app | othervoucheri nvitecodeslott erygift | email | phone | website | malware | exploits | hosting | RAT | botnet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lifespan | Pearson Correlation | 1 | ,149 | ,197 | ,144 | ,101 | ,161 | ,066 | ,167 | ,067 | ,068 | ,074 | ,103 | ,130 | ,089 | ,069 | ,058 | ,056 | ,052 |
| | Sig. (2-tailed) | | ,000 | ,000 | ,000 | ,011 | ,000 | ,098 | ,000 | ,093 | ,088 | ,062 | ,009 | ,001 | ,025 | ,082 | ,143 | ,161 | ,191 |
| | N | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 | 635 |

Figure 2: Results linear regression for market Alphabay



Correlations

| | | lifespan | otherguide | cashout | other | otheraccount | othercustom | otherpirateds oftware | otherfake | app | othervoucheri nvitecodeslott erygift | email | phone | website | malware | exploits | hosting | RAT | botnet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lifespan | Pearson Correlation | 1 | ,246 | ,450 | ,325 | ,232 | ,377 | ,144 | ,427 | ,150 | -,003 | ,222 | ,280 | ,250 | ,238 | ,196 | ,168 | ,230 | ,230 |
| | Sig. (2-tailed) | | ,012 | ,000 | ,001 | ,018 | ,000 | ,146 | ,000 | ,130 | ,975 | ,024 | ,004 | ,011 | ,016 | ,048 | ,089 | ,019 | ,019 |
| | N | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |

Figure 3: Results linear regression for market Black Market Reloaded

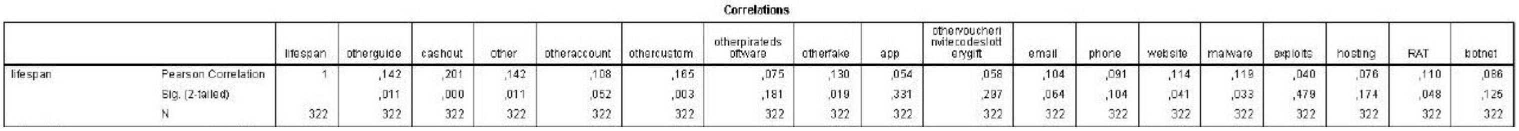
As can be seen, some categories have a noticeably stronger correlation with the lifespan of the seller than others. Cashouts for example have a correlation of 0.2, whilst botnets only have a correlation of 0.052 on the Alphabay market. While it is of course not possible to infer causation from this data, it is a strong indication of certain types of goods being associated with succesful vendors. Our expectation is that cashouts are an item with much more demand, are easier to sell since there is much less value per transaction, and has less information asymmetry than botnets. We think this is why on average selling cashouts is associated with vendors with longer lifespans.

## 2.4 Conclusion

In the first part of this report we analysed three actors (problem owner, law-enforcement agencies and law makers) to a further extend. Identifying countermeasures, analyzing the cost/benefit distribution and analysing their incentives as well as reflecting on the externalities surrounding this security issue.

The second part of the report was dedicated to identifying the type of actor whose performance is visible in the security performance metric, which were the market owners in this report. The metric, the cumulative lifespan of the top 20% vendors of the markets, showed clear differences in the security for each market. Using the assumption as mentioned in that section, that more successful vendors means the market has a better security. A few factors have been identified that could influence the security performance, like transaction fees, the market's reputation, the payment services available, type of goods solds and availability of escrow service or other scam countermeasures.

For the analysis we chose to use the factor of 'Type of good solds' and applied a pearson correlation analysis as well as linear regression for our statistical analysis. The pearson correlation analysis used cohen's standard, as explained in that section, for attributing the strength of the association to different values. It was



Correlations

| | | lifespan | otherguide | cashout | other | otheraccount | othercustom | otherpiratedsoftware | otherfake | app | othervoucherinvitecodeslotterygift | email | phone | website | malware | exploits | hosting | RAT | botnet |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lifespan | Pearson Correlation | 1 | ,142 | ,201 | ,142 | ,108 | ,165 | ,075 | ,130 | ,054 | ,058 | ,104 | ,091 | ,114 | ,119 | ,040 | ,076 | ,110 | ,086 |
| | Sig. (2-tailed) | | ,011 | ,000 | ,011 | ,052 | ,003 | ,181 | ,019 | ,331 | ,297 | ,064 | ,104 | ,041 | ,033 | ,479 | ,174 | ,048 | ,125 |
| | N | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 | 322 |

Figure 4: Results linear regression for market Evolution

observed that in the period of the start of a market, the correlation values were higher but that these declined the more mature the market became. It could be a result of the market attracting new vendors and items in certain categories of goods start to be sold as the market is 'new' and has yet to be discovered. This could be used to explain that there is no strong association between the categories and the cumulative lifespan of the vendors. The linear regression analysis gave a strong indication of certain types of goods being associated with successful vendors. One category of goods, the cash-outs, have a low price what could have resulted in more items of this category being sold and thus resulting in a larger association in the analysis.

# References

*Correlation (pearson, kendall, spearman).* (n.d.). Retrieved from http://www.statisticssolutions.com/correlation-pearson-kendall-spearman/

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | SK1 | 0.25 | 0.24 | 0.27 | 0.24 | 0.21 | 0.22 | 0.2 | 0.19 | 0.18 | 0.17 | 0.16 | 0.16 | 0.16 | 0.15 | 0.15 | 0.14 | 0.14 |
| 2012 | EVO | 1.0 | 0.64 | 0.75 | 0.81 | 0.72 | 0.73 | 0.66 | 0.6 | 0.54 | 0.5 | 0.51 | 0.52 | 0.5 | 0.48 | 0.46 | 0.44 | 0.43 |
| 2012 | SK1 | 0.31 | 0.23 | 0.28 | 0.26 | 0.23 | 0.24 | 0.22 | 0.21 | 0.2 | 0.19 | 0.18 | 0.18 | 0.18 | 0.17 | 0.16 | 0.16 | 0.16 |
| 2012 | SK2 | 0.99 | 0.72 | 0.79 | 0.84 | 0.76 | 0.78 | 0.72 | 0.66 | 0.61 | 0.57 | 0.59 | 0.59 | 0.57 | 0.55 | 0.53 | 0.51 | 0.49 |
| 2013 | BKR | 0.32 | 0.31 | 0.31 | 0.27 | 0.24 | 0.24 | 0.22 | 0.21 | 0.2 | 0.19 | 0.18 | 0.17 | 0.17 | 0.16 | 0.15 | 0.15 | 0.15 |
| 2013 | EVO | 0.46 | 0.35 | 0.25 | 0.22 | 0.19 | 0.22 | 0.2 | 0.19 | 0.17 | 0.16 | 0.16 | 0.16 | 0.15 | 0.15 | 0.14 | 0.14 | 0.13 |
| 2013 | SK1 | 0.29 | 0.26 | 0.27 | 0.26 | 0.24 | 0.24 | 0.23 | 0.22 | 0.21 | 0.2 | 0.19 | 0.18 | 0.18 | 0.17 | 0.17 | 0.16 | 0.16 |
| 2013 | SK2 | 0.47 | 0.37 | 0.42 | 0.4 | 0.36 | 0.36 | 0.34 | 0.33 | 0.27 | 0.26 | 0.25 | 0.25 | 0.24 | 0.23 | 0.22 | 0.21 | 0.21 |
| 2013 | AGO | 0.63 | 0.45 | 0.37 | 0.38 | 0.33 | 0.35 | 0.32 | 0.3 | 0.24 | 0.23 | 0.22 | 0.22 | 0.21 | 0.21 | 0.2 | 0.19 | 0.19 |
| 2013 | PAN | 0.56 | 0.48 | 0.44 | 0.38 | 0.34 | 0.32 | 0.29 | 0.28 | 0.26 | 0.25 | 0.24 | 0.23 | 0.22 | 0.21 | 0.21 | 0.2 | 0.19 |
| 2013 | ALP | 0.93 | 0.57 | 0.39 | 0.43 | 0.37 | 0.37 | 0.35 | 0.32 | 0.3 | 0.29 | 0.28 | 0.28 | 0.27 | 0.26 | 0.25 | 0.24 | 0.24 |
| 2014 | BKR | 0.2 | 0.22 | 0.19 | 0.17 | 0.16 | 0.14 | 0.15 | 0.14 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 |
| 2014 | EVO | 0.21 | 0.19 | 0.17 | 0.14 | 0.13 | 0.12 | 0.11 | 0.11 | 0.1 | 0.1 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 |
| 2014 | SK1 | 0.5 | 0.33 | 0.33 | 0.16 | 0.15 | 0.13 | 0.12 | 0.12 | 0.11 | 0.1 | 0.1 | 0.1 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| 2014 | SK2 | 0.34 | 0.26 | 0.25 | 0.16 | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.1 | 0.1 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 |
| 2014 | HYD | 0.6 | 0.59 | 0.46 | 0.41 | 0.37 | 0.34 | 0.25 | 0.23 | 0.22 | 0.22 | 0.21 | 0.2 | 0.19 | 0.18 | 0.18 | 0.17 | 0.17 |
| 2014 | AGO | 0.29 | 0.23 | 0.21 | 0.14 | 0.13 | 0.12 | 0.11 | 0.1 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 |
| 2014 | PAN | 0.27 | 0.32 | 0.26 | 0.23 | 0.22 | 0.2 | 0.2 | 0.19 | 0.18 | 0.17 | 0.17 | 0.16 | 0.16 | 0.15 | 0.14 | 0.14 | 0.14 |
| 2014 | ALP | 0.24 | 0.08 | 0.09 | 0.11 | 0.1 | 0.09 | 0.09 | 0.08 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 |
| 2015 | BKR | 0.27 | 0.28 | 0.25 | 0.21 | 0.19 | 0.18 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.14 | 0.13 | 0.13 | 0.12 | 0.12 | 0.11 |
| 2015 | EVO | 0.14 | 0.2 | 0.18 | 0.17 | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 | 0.11 | 0.11 | 0.11 | 0.1 | 0.1 | 0.1 | 0.09 | 0.09 |
| 2015 | SK1 | 0.43 | 0.43 | 0.5 | 0.27 | 0.24 | 0.22 | 0.21 | 0.19 | 0.19 | 0.18 | 0.17 | 0.17 | 0.16 | 0.16 | 0.15 | 0.15 | 0.14 |
| 2015 | SK2 | -0.17 | 0.26 | 0.29 | 0.25 | 0.23 | 0.21 | 0.19 | 0.18 | 0.18 | 0.17 | 0.16 | 0.15 | 0.15 | 0.14 | 0.14 | 0.13 | 0.13 |
| 2015 | HYD | 1.0 | 0.96 | 0.7 | 0.59 | 0.55 | 0.5 | -0.01 | -0.01 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2015 | AGO | 0.33 | 0.28 | 0.31 | 0.2 | 0.18 | 0.16 | 0.17 | 0.16 | 0.16 | 0.15 | 0.14 | 0.14 | 0.13 | 0.13 | 0.12 | 0.12 | 0.12 |
| 2015 | PAN | -0.59 | 0.22 | 0.18 | 0.15 | 0.13 | 0.12 | 0.18 | 0.17 | 0.16 | 0.15 | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 | 0.12 | 0.12 |
| 2015 | ALP | 0.12 | 0.2 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.1 | 0.1 | 0.1 | 0.09 | 0.09 | 0.09 |
| 2016 | BKR | -0.99 | 0.26 | 0.2 | 0.17 | 0.13 | 0.12 | 0.16 | 0.15 | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.1 | 0.1 | 0.1 |
| 2016 | EVO | 0.19 | 0.05 | 0.08 | 0.1 | 0.09 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 |
| 2016 | SK2 | -0.62 | 0.11 | 0.24 | 0.22 | 0.19 | 0.18 | 0.17 | 0.16 | 0.16 | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 | 0.12 | 0.12 | 0.11 |
| 2016 | AGO | 0.26 | 0.3 | 0.26 | 0.18 | 0.16 | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.1 | 0.1 | 0.1 | 0.09 |
| 2016 | PAN | - | 0.55 | 0.44 | 0.37 | 0.33 | 0.3 | 0.28 | 0.26 | 0.24 | 0.23 | 0.22 | 0.21 | 0.2 | 0.19 | 0.19 | 0.18 | 0.17 |
| 2016 | ALP | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.1 | 0.1 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 |

Table 2: Pearson correlation for all categories per market per year.