

Measuring the Deterioration of Trust on the Dark Web: Evidence from Operation Bayonet

Scott Lee Chua (Yale-NUS College)

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Ten Years Since...



Image from [Cointelegraph](#) and [Forbes](#).

Motivation

- How do we evaluate success of law enforcement (LE) operations on darknet markets?
 - Demand: ↓ in short run, ↑ in long run [1, 2]
 - Supply: displaced, not deterred [3, 4]
 - Prices: neither rise nor fall [5, 6]
 - Darknet market ecosystem continues to grow (COVID-19) [7, 8]
- What to conclude?
- How else have LE operations impacted the market?

Measuring Trust

- Darknet markets are anonymous, illegal, online
 - **Trust** crucial for market functioning [9, 10]
 - Valid target for LE operations
- How to measure (change in) trust?
- I propose **vendors' returns on reputation (RoR)**
 - $\text{RoR} \rightarrow \text{trust} \rightarrow \text{LE success}$
- Intuition: $\partial \$\$ / \partial \text{reputation}$
- RoR is...
 - Easily interpreted (" β ")
 - Data required is available
 - Well-studied in industrial org literature

Rating as Reputation

Browse by category

Drugs 61995

• Opioids 4570

- › Buprenorphine 145
- › Codeine 79
- › Dihydrocodeine 20
- › Heroin 2937
- › Hydrocodone 61
- › Hydromorphone 54
- › Morphine 73
- › Opium 108
- › Other 135
- › Oxycodone 536

Digital Goods 51322

Drugs 61995

Drugs Paraphernalia
359

Services 5051

Other 4290

Opioids (4570)

Filter

Ships to Ships from Escrow Category Cryptocurrency

Price Searchtext Sort by Vendor

1 2 3 4 5 6 7 8 9 dutchglory (2000) (4.85★) 16 17

18 19 20 ... 134 135 136 137

★NEW★ 4 GR PURE Afghan #3 Heroin

B0.02489
dutchglory (2000) (4.85★)
BE → EU, WW

Order

!!!NEW!!! TURKISH HEROIN-HIGHEST QUALITY
9.5GR

B0.0542
kitkatNL (700) (4.86★)
NL → WW

Order

Dream market user interface. Image from [Dreammarket.link](https://www.dreammarket.link).

Returns on Reputation

- Positive RoR shown:
 - On clearnet: eBay [11], Taobao [12]
 - **And** on darknet: Silk Road [13], Hansa [14]
 - Reputable → higher price markups!
- How does RoR change in response to LE operations?

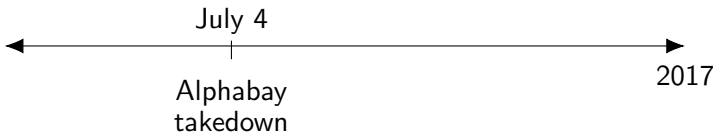
Hypothesized Mechanism

- Intuition: buyers use vendor's ★ rating (reputation) to trade off between price premium and risk
 - Risk-averse: high price $\Leftrightarrow$ reputable vendor
 - Risk-loving: low price $\Leftrightarrow$ “shady” vendor
- ★ rating captures all notions of reputation...
 - “Objective”: quality product, prompt delivery
 - “Subjective”: trustworthy, feeling safe

Hypothesized Mechanism

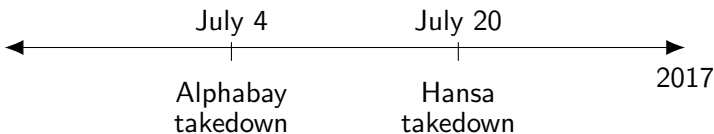
- If LE operation **does not** damage buyer's trust in vendors:
 - No change in buyers' tradeoffs, vendors' RoR
- If LE operation **does** damage trust:
 - Vendor's *a priori* reputation becomes important signal!
 - Higher ★ rating buffers vendors against fall in trust
 - Some buyers "switch" to more reputable vendors → RoR ↑
- Validate with **event study**

Operation Bayonet



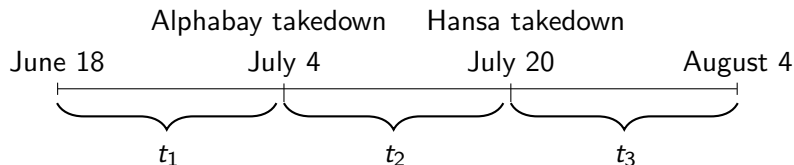
- Led by FBI, Dutch police in 2017
- “Standard” takedown: did not damage trust in vendors Notice
- Users moved to next-largest market, Hansa...

Operation Bayonet



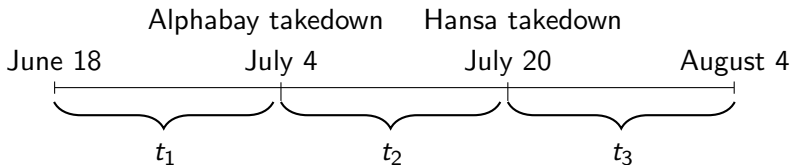
- ... but Hansa's admin, as well as some vendors, were already controlled by Dutch police!
- After 16 days, Hansa was taken down Notice
- "Impersonation campaign" sowed distrust across dark web

Predictions



- t_1 to t_2 : no change in trust → **no change** in RoR
- t_2 to t_3 : fall in trust → **increase** in RoR

Data



- All reviews on **Dream market** (3rd largest) from t_1 to t_3 [15]
- Aggregated to vendor- t level ($n = 4,723$) Summary stats

Model

$$y_{it} = \gamma_1 Alpha_t + \gamma_2 Hansa_t + \gamma_3 \star_{it} \\ + \delta_1 Alpha_t \cdot \star_{it} + \delta_2 Hansa_t \cdot \star_{it} + \beta' X_{it} + \alpha_i + \epsilon_i$$

indexed by vendor i and time t , where:

- y_{it} is vendor's mean revenue OR market share
- $Alpha_t, Hansa_t$ are takedown dummies
- $\star_{it}$ is vendor's mean star rating
- X_{it} are controls, α_i is a fixed effect, ϵ_i is an error term

Coefficients of Interest

$$y_{it} = \gamma_1 \text{Alpha}_t + \gamma_2 \text{Hansa}_t + \gamma_3 \star_{it} \\ + \delta_1 \text{Alpha}_t \cdot \star_{it} + \delta_2 \text{Hansa}_t \cdot \star_{it} + \beta' X_{it} + \alpha_i + \epsilon_i$$

- δ_1 is effect of Alphabay takedown on RoR
 - expect $\delta_1 = 0$
- δ_2 is additional effect of Hansa takedown on RoR
 - expect $\delta_2 > 0$

Results

This is exactly what we find!

	Log meanrevenue		Log mktshare	
	(1)	(2)	(3)	(4)
★ rating	-0.00581 (-0.06)	-0.0143 (-0.17)	0.0457 (0.30)	0.0197 (0.16)
Alphabay × ★ rating	-0.112 (-1.01)	-0.0885 (-0.88)	-0.207 (-1.14)	-0.142 (-0.95)
Hansa × ★ rating	0.377*** (3.32)	0.325** (2.80)	0.687*** (3.92)	0.565** (3.28)
Alphabay	0.675 (1.24)	0.552 (1.13)	0.302 (0.34)	-0.000903 (-0.01)
Hansa	-1.877*** (-3.40)	-1.592** (-2.82)	-3.003*** (-3.52)	-2.299** (-2.74)
Controls	No	Yes	No	Yes
Adjusted R^2	0.161	0.211	0.244	0.341
Observations	4723	4723	4723	4723

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Dream: Market Share

	t_1	t_2	t_3
Reputable market share	31.12	10.68	15.08
New vendors	32	277	77

"Reputable": vendors with above-median ★ rating

- t_1 to t_2 : reputable vendors' market share ↓
 - Alfabay users migrating to Dream
- t_2 to t_3 : reputable vendors' market share ↑
 - Damaged trust: buyers switch to higher-★ vendors!
 - Consistent with hypothesized mechanism

Robustness

- Regression results are robust to
 - z-scoring ★ rating
 - other specifications for reputation
 - different assumptions on review data latency
- Placebo test: In a market where user identities are verifiable, impersonation campaign had **no effect on RoR!** Valhalla

Implications

- Damaging buyer trust raises vendor barriers to entry!
 - Fewer, more conspicuous vendors [16]
- RoR seems a good proxy for (change in) trust
 - Wider toolbox to evaluate LE impersonations/ “psy-ops”
- Thank you!

Alphabay takedown notice

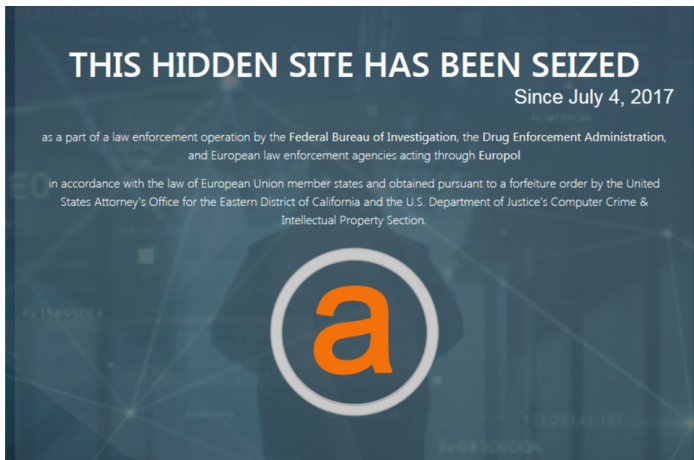


Image from [Wikipedia](#). [Back](#)

Hansa takedown notice



Image from [Quartz.com](#).

Back

Summary Statistics

	t_1			t_2			t_3			Description
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	
meanrevenue	678.10	245.05	1,491.39	874.45	292.42	2042.97	711.69	258.30	1,439.63	mean revenue / transaction, USD
mktshare	0.082	0.000	0.506	0.056	0.000	0.398	0.057	0.000	0.292	vendor's share of period sales, %
meanrating	4.87	5.00	0.38	4.86	5.00	0.35	4.85	4.985	0.33	period mean star rating
fivestars	30.86	13.00	49.29	44.05	18.00	79.11	49.95	22.00	78.97	number of 5-star reviews
meanuntil	4.76	4.92	0.74	4.57	4.92	1.18	4.79	4.92	0.60	lifetime mean star rating
txns	39.96	17.00	65.96	59.01	25.00	97.71	48.55	20.00	77.52	number of period transactions
txnsuntil	159.82	65.00	247.91	140.35	40.00	269.93	186.81	64.50	346.74	number of past transactions
diversity	0.312	0.355	0.288	0.308	0.346	0.290	0.285	0.260	0.289	HHI index, 1 is most diverse
new vendors	32			277			77			vendors with no sales before t
total vendors	1,219			1,772			1,736			vendors who made a sale in t

Summary statistics (mean, median, standard deviation) of Dream vendor-level variables, by time period. [Back](#)

Placebo: Valhalla

- Valhalla is a closed-door darknet market
- Registering on Valhalla (as buyer or vendor) requires a “referral link” from an existing user [17]
- Theoretically, the true identity of each Valhalla user would be known by at least one other user → more resistant to impersonation campaigns
- Expect Operation Bayonet to have **no effect at all** on vendor RoR

Valhalla Results

	Log revenue per transaction		Log market share	
	(1)	(2)	(3)	(4)
thumbsup	-0.0168 (-0.89)	-0.0181 (-0.98)	-0.000369 (-0.02)	-0.00463 (-0.20)
Alphabay × thumbsup	0.0117 (0.45)	0.0210 (0.76)	-0.0372 (-1.06)	-0.0101 (-0.27)
Hansa × thumbsup	0.00745 (0.53)	-0.000582 (-0.03)	0.0383 (1.54)	0.0178 (0.72)
Alphabay	-0.212 (-1.31)	-0.239 (-1.34)	-1.771*** (-7.91)	-1.836*** (-7.92)
Hansa	-0.00135 (-0.01)	0.0346 (0.25)	-0.736** (-3.30)	-0.632** (-2.86)
Adjusted R^2	0.111	0.132	0.711	0.739
Additional dummies	No	Yes	No	Yes
Observations	314	314	314	314

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ [Back](#)

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