

Entrepreneurs on the Darknet: Reaction to Negative Feedback

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Abstract

Reputation is one of the key assets of a digital entrepreneur in markets for experience goods, especially in settings like *Darknet* and anonymous marketplaces. But what happens if this asset is diminished by a shock, i.e. negative feedback? We study how entrepreneurs on anonymous marketplaces respond to negative feedback by adjusting their product portfolio, or even exiting the market altogether. We find that the entrepreneurs are more likely to exit following negative feedback, but that an entrepreneur's accumulated transactions experience on the market platform negatively moderates this. Interestingly, the entrepreneurs that do remain tend to expand their product portfolio. This effect, however, is again driven by entrepreneurs with relative high transactions experience, i.e. those with a high prior transactions volume. These results suggest that the reputation and the transactions experience of an entrepreneur interact in intricate ways to drive an entrepreneur's choice of remaining in the market or adjusting her portfolio. We derive managerial and policy implications of these results.

Keywords: Digital Entrepreneurship, Reputation, Anonymous Marketplaces, Illicit Drugs, Darknet

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1. Introduction

The *Darknet* is becoming an increasingly popular place for entrepreneurs to engage in grey or black market activities. The *Darknet* has emerged in recent years as an infrastructure unaffected by growing privacy and security concerns on the mainstream internet and facilitates anonymous and untraceable transactions, creating an attractive environment for the trade of illegal goods and services¹. Inherent to the *Darknet's* anonymity is the fact that many of the marketplaces selling illegal goods via the *Darknet* were able to evolve and grow without any regulatory oversight and intervention. This implies that transactions on the *Darknet* are governed by different principles as contracts are not enforceable in court and transaction partners typically never meet or even know each other's whereabouts.

Digital "*Darknet* entrepreneurs" have the same fundamental goals as conventional ones: They spot a market opportunity, assemble the required resources, and move to fill the opportunity gap. Once entered, they try to remain in business (survival as the first goal) and ultimately grow their operations (growth as the second goal)(Lewis and Churchill, 1983; Scott and Bruce, 1987). The fundamental difference is how they achieve their goals in markets in which it is impossible (and unwanted) to build personal relations and rapport with customers. For experience goods, this is especially challenging as the quality of a good or service cannot be ascertained prior to completing the transaction (Nelson, 1970, 1974; Riordan, 1986). *Darknet* entrepreneurs have to rely almost exclusively on reputation built and communicated publicly, while conventional entrepreneurs can use prior transactions with existing customers to build relationship-specific trust or use their brand name as a mechanism to provide information about quality (Tadelis, 1999). Hence, reputation (for quality, reliability, speedy delivery etc.) is a core asset for digital entrepreneurs, especially those operating on *Darknet* marketplaces (Goldfarb and Tucker, 2017; Rindova et al., 2010), and

¹We describe the *Darknet* in more detail in Section 2

the strategic management of reputation is crucial to achieve an entrepreneur’s goals (Weigelt and Camerer, 1988).

Just as offline criminal entrepreneurs have been shown to respond to economic incentives (Levitt and Venkatesh, 2000; Clay, 1997; Greif, 1989), online entrepreneurs that engage in a significant amount of transactions and consequently draw a significant portion of their income from illegal online sales will respond to changes in their environment and competitive position. We study the strategic actions of such “*Darknet* entrepreneurs” on one of the largest platform for illicit goods and services in its time, *Agora*. In doing so, we combine two unique features of the *Agora* marketplace and the entrepreneurs active on it. First, *Darknet* entrepreneurs have few other instruments or features (like participating in the forum of a marketplace in the case this marketplace has a forum, or changing the self description) that set them apart from their competitors except for their accumulated reputation, so that a change in an entrepreneur’s reputation will likely trigger a response. Second, it is relatively easy for *Darknet* entrepreneurs to adjust their portfolio as supply of drugs (the category we study) is a relatively flexible market, with most suppliers offering a wide range of drugs that can then be sold by entrepreneurs on *Darknet* marketplaces. Hence, our concrete research question is: *Will Darknet entrepreneurs adjust their product portfolio in response to negative feedback and if so, how?*

We focus on two possible reactions: First, entrepreneurs can exit the market if they suffer from negative feedback. Their expected profits from each transaction decline (Bhaskar et al., 2017). As a consequence entrepreneurs may simply leave to pursue other opportunities or to take their activities to another (online or offline) market. We call this the *extensive margin*, i.e. the decision to operate in a market at all. Second, entrepreneurs can adjust their portfolio of listings in response to negative feedback, i.e. the mix and amount of products they sell. This could either result in a contraction of the products offered to focus on the most profitable items, or in an expansion to rebuild reputation and diversify away from the existing range of offerings. Changes in the extent and composition of an entrepreneur’s offerings refer to the *intensive margin*.

Using an extensive dataset on transactions and entrepreneurs on *Agora*, we find that the response to negative feedback is contingent on the entrepreneur’s transactions experience, i.e. how many prior transactions she has completed: If she has a relatively short history of transactions on the marketplace, she is more likely to exit the market as a response to negative feedback, i.e. adjust the *extensive margin*. Conversely, if an experienced entrepreneur suffers from negative feedback, the response will likely be an expansion of the entrepreneur’s listings, i.e. adjusting the *intensive margin*. This contributes to our understanding of illegal digital markets and the actors active on them, but more broadly we offer evidence that entrepreneurial responses to adverse shocks may depend on the entrepreneur’s transactions experience and the reputation accumulated. Ours is the first study to show this contingency of responses to our knowledge.

2. The Darknet and Anonymous Marketplaces

An anonymous marketplace is an “online forum where goods and services are exchanged between parties who use digital encryption to conceal their identities” (Martin, 2014b). Anonymous marketplaces are a recent phenomenon enabled by advances in technology in the past years (Martin, 2014b). The increasing usability of encryption software combined with growing scepticism regarding the privacy of conventional online markets made it increasingly attractive to access anonymous marketplaces (Christin, 2013).

The *Darknet* itself and the anonymous marketplaces embedded therein are largely based on two technological components, namely the Tor network that enables navigating without giving up anonymity and cryptocurrencies to complete anonymous transactions remotely. The combined use of these two components assures anonymous communication and exchange among users, with a relatively low risk of being detected (Barratt et al., 2014; Décary-Hétu and Aldridge, 2015; Martin, 2014a).

The Tor network is a free “circuit based low-latency communication service” (Syverson et al., 2004), which uses encryption software and is only accessible via

the Tor browser. Tor allows users to interact online without exposing their identity or physical location (Martin, 2014a). Accessing the internet via conventional means uses traditional DNS routing, which is mapped to a unique IP address and therefore, allows identifying the user. Conversely, Tor uses onion routing, which encrypts the path of communication between the client and the server in several layers. Hence, anonymous websites have the the suffix ‘.onion’ (Bradbury, 2014). A user contacts the server and chooses a random path to disguise the original entry point. Tor then sets up a rendezvous point inside the network, which allows communication between server and client. The communication remains encrypted until accessing the rendezvous point, whereby the latest IP address will be transmitted instead of the original obfuscated IP address. This allows anonymous communication between server and client (Christin, 2013; Bradbury, 2014). The Tor network was first developed in the early 90s by the US Navy to ensure anonymity of US intelligence online communication services (Bhaskar et al., 2017).

The other important technological element that helped the growth of anonymous marketplaces is the use of cryptocurrencies. Cryptocurrencies are digital currencies which make tracing payment transactions virtually impossible (Hardy and Norgaard, 2016). Other than for traditional currencies, these currencies are not ruled by any institution or regulation. The most prominent cryptocurrency is Bitcoin (BTC). It is a software package which contains a wallet file in which users store their bitcoins and an individual access point for the user within the network. The blockchain data structure verifies all Bitcoin activities. Bitcoins are recorded as transaction, which means that the creation of BTC follows a prescribed track and provides an index of past transactions meaning that each BTC can be traced back (Böhme et al., 2015). Therefore, the entire chain of transactions is public, yet the owner remains anonymous due to the use of pseudonyms. Since the introduction in 2009, the Bitcoin system was used for more than 220 million transactions (Narayanan et al., 2016).

The high level of anonymity makes it difficult for law enforcement agencies to intervene in such markets, which attracted black market activities like the

trade of illicit drugs (Hardy and Norgaard, 2016). Thus, entrepreneurs could do business at unprecedented scale at a lower risk of organized crime or drug-related violence compared to conventional black market activity by eliminating any physical interaction between trading partners (Décary-Hétu and Aldridge, 2015; Martin, 2014a; Soska and Christin, 2015). Still, the landscape of anonymous marketplaces on the *Darknet* remains fluid and affected by platforms disappearing due to arrests, scam exits and high competition (Soska and Christin, 2015).

Moreover, these platforms do not offer illicit goods on their own. As all platforms, they merely provide the adequate infrastructure for buyers and sellers to conduct transactions on their own (Cennamo and Santalo, 2013; McIntyre and Srinivasan, 2017). Recent platforms have become comparable to Amazon or eBay in their appearance and user-friendliness. Sellers can promote their goods, and buyers can order goods and rate transactions with respect to their perceived satisfaction of product quality, customer service and seller trustworthiness (Martin and Christin, 2016; Martin, 2014a; Aperjis and Johari, 2010; Rice, 2012; Hagiú and Wright, 2015; Hui et al., 2016). Buyers then deposit their payment to the wallet, which is held in escrow until the payment is released by the buyer (Zajác, 2017). The escrow service is offered as a payment service on most anonymous platforms by default. Typically, payment is transferred to the seller only with the authorization of at least two of three parties (seller, buyer and administrator), in general through the approval of the buyer (Christin, 2013). The escrow service is necessary because prepayment carries the risk for abuse, so that escrow services create and signal trust (Christin, 2013; Martin, 2014a; Soska and Christin, 2015). After a successful transaction, the seller is charged with a commission fee ranging from 1.5% to 10%, depending on the sales volume (Christin, 2013).

Most anonymous marketplaces then share the following characteristics: they *are located within the Tor network, make use of pseudonyms to protect the user's identity, dispatch goods via traditional delivery services, use third-party hosting and administration, use decentralized exchange networks, make use of encrypted digital currencies, and use escrow service.*

Since anonymous marketplaces and the *Darknet* are relatively recent phenomena and due to their opaque nature, the literature on anonymous marketplaces is relatively scarce. Most existing literature has focused on the legal implications or the technological functionality studied by computer scientists. Computer science has mainly focused on sizing the phenomenon of illegal online activity. Christin (2013) first studied anonymous marketplaces systematically and measured seller activity on *Silk Road*, the first sophisticated anonymous marketplace. Soska and Christin (2015) continued this work by measuring the overall activity of 35 marketplaces. They have found that total sales volumes are around \$300,000-\$500,000 a day, demonstrating the importance of anonymous marketplaces. In the criminology literature, Martin (2014b) studied the implications of *Silk Road* for drug consumers and law enforcement. Most work in this domain has focused on the effect of *Operation Onymous*, a raid on 5 anonymous marketplaces, including the largest one at the time, or on other comparable law enforcement operations (Décary-Hétu and Giommoni, 2017; Buskirk et al., 2017). Further, scholars have tried to understand users' experiences and sellers' self-perception on *Silk Road* (Van Hout and Bingham, 2013, 2014), while Moeller et al. (2017) point out that information asymmetries between sellers and buyers still exist in illicit drug online markets.

Recent work in economics addresses the important relationship between reputation and other outcome variables of internet sellers. Hardy and Norgaard (2016) use data from *Silk Road* to study the relationship between reputation and prices and show that investment in reputation provides a premium to entrepreneurs, which is in line with Bhaskar et al. (2017), who demonstrate that online black markets manage to alleviate moral hazard problems, predominantly because negative feedbacks lead to sales reductions. Similarly, Janetos and Tilly (2017) show that bad (i.e. low-ranked) sellers prefer to exit the market than decrease their prices in response to negative feedback. Finally, Armona (2017) measure the impact of informal communication (through forum discussions) in anonymous marketplaces, and find evidence that as the number of messages grows product demand is growing.

Both the technical and commercial characteristics of anonymous marketplaces and the empirical findings suggest that managing reputation and responding appropriately to (negative) shocks to reputation are key determinants in the success on entrepreneurs on anonymous marketplaces.

3. Entrepreneurs, Reputation and Online Marketplaces

We consider an entrepreneur as someone who derives a significant part of her income from the entrepreneurial activity and someone who actively strives to increase the profitability of said activity. There is also ample evidence that reputation has to be built up over a longer period in online marketplaces, which will render opportunistic sellers entering in a grab-and-exit manner relatively less important than entrepreneurs with a longer time horizon.

As to the latter, we study and find support for the intuition that our subjects actively manage their activities in response to negative feedback, which suggests directed, profit-enhancing behaviour. Regarding the question of whether the sellers we study sell on Agora as a full-time activity or as a part-time, anonymity of course makes it difficult to ascertain this for sure. However, a look at the statistics shows that the median age of the vendors is 22 weeks (with the maximum being 79) meaning that they stay in this market for at least one quarter of the total age of the market, and almost five months on average. The median number of transactions is 2048, and the median number of seller's revenues is almost \$16000. Moreover, more than one third (35,91%) of sellers are multihomers according to a fairly strict definition (having the same username on all three major platforms, *Agora*, *Silk Road 2* and *Evolution*). In addition to, each seller offers 15 products in two different drug categories at any time on average. This again suggests that sellers are profit-oriented individuals actively seeking profit opportunities, which is consistent with thinking of them as entrepreneurs. Also, Caulkins et al. (1999) after conducting interviews with drug dealers in New York City have found that half of them can be considered as entrepreneurs. Whenever we discuss the specific empirical setting, however, we

will refer to them as sellers, because this ultimately best describes the activity they pursue on Agora.

Given the anonymity of spatial separation between customers and entrepreneurs on online marketplaces, moral hazard issues are more prevalent in such markets. To solve these issues and create trust on both sides of the market, reputation systems have been implemented and improved, which helped online marketplaces attract quality products and sellers (Tadelis, 2016; McIntyre and Srinivasan, 2017; Cabral, 2012). Reputation systems work through feedback: buyers evaluate sellers, and in some cases sellers also can evaluate buyers (e.g. *Airbnb*).

Social learning, i.e. collective learning via public reputation systems, facilitates the rapid gain and spread of knowledge that might be difficult, costly, or dangerous to acquire by first-hand experience (Powell et al., 2017). Buyers can observe the feedback of buyers with direct experience and can update their beliefs concerning the quality of a seller through observing the feedback of many other buyers. The most salient measure of prior performance is the average rating of a buyer. However, the value of a high average rating is contingent on the number of transactions that led to it. A few successful transactions may still be a fluke, whereas a long history of successful transactions is a good indicator of reliable business practices and high-quality products. Hence, buyers take the number of reviews a product/seller has accumulated into account to understand better how precise the sellers' average rating is (Powell et al., 2017).

A wide body of work confirms the important role of feedback systems in online marketplaces. The effect of positive feedback on sales has been demonstrated (Chevalier and Mayzlin, 2006), in line with studies that have shown that sellers that are better rated have higher prices and consequently generate higher revenues (Melnik and Alm, 2002; Livingston, 2005; Lucking-Reiley et al., 2007).

A common feature of online marketplaces and platforms like *Uber* and *Airbnb* is the inflation of positive feedback (Fradkin et al., 2016; Filippas et al., 2017). The average rating is likely to be high for most continuing actors on a platform. As a consequence, negative feedback carries a strong informative signal, since it is so rare to receive (or give) negative feedback, which therefore receives more

weight than positive feedback (Ba and Pavlou, 2002). Importantly, with the inflation of positive feedback, the number of confirmed prior transactions can still play the same (if not more) crucial role in the perceived reliability of the seller.

Regarding negative feedback, (Cabral and Hortaçsu, 2010) show the effect of negative feedback on eBay. (Cabral and Hortaçsu, 2010) demonstrate that when a seller receives the first negative feedback her weekly sales growth decreases from +5% to -8%. They also demonstrate that following the first negative feedback, further negative feedback arrives at a higher rate, suggesting decreased effort on the part of the seller. Relatedly, research on Yelp by Luca (2011) has shown that online restaurant reviews impact restaurant demand, especially for independent restaurants, a result which has been confirmed for hotels by Hollenbeck (2016). Again in the restaurant setting, Lehman et al. (2014) have tested how consumers take value out of reviews and how they act when evaluating the hygiene reviews of restaurants. On the Airbnb platform, Fradkin et al. (2016) study how choices in the design of the marketplace affect the ability of ratings and reviews to aggregate information. Finally, Wagner (2016), in a field experiment in a Chilean startup accelerator, found that negative feedback decreases the probability of startup continuation, i.e. increases the probability of exiting the market.

4. Entrepreneurs' Responses to Negative Feedback

As mentioned above, negative feedback constitutes a fundamental threat to entrepreneurs in many platform markets because they typically hold few other distinctive assets, and even more so on the *Darknet*, where other drivers of reputation or brand equity (e.g. advertising, location, human capital) are not visible or available to entrepreneurs. Hence, it is crucial for *Darknet* entrepreneurs to manage their reputation, which is driven by two features specific to online marketplaces: the number and the average rating of transactions. Cabral (2012) shows that entrepreneurs respond to negative feedback because they have an

incentive to restore their reputation.

Suffering a drop in reputation also affects the expected profits from a transaction (Cabral and Hortaçsu, 2010). One response might therefore be that *Darknet* entrepreneurs focus on activities that are most profitable and deemphasize all others. However, the incentive to restore reputation may call for an increased level of activity, either to offset the statistical effect of the negative rating and/or to obfuscate the effect by introducing more and other activities, which reduces the reliance, increases uncertainty (Rice, 2012) and thus the signalling power of the negative rating. Which of these two forces dominates is not obvious.

However, the forces towards expansion or contraction of activities are expected to interact with the other source of reputation, the number of prior transactions, in specific ways. If an entrepreneur has not yet accumulated a large number of prior experience, a negative rating will have two immediate effects: First, a negative rating will have a relatively greater negative impact on average rating, which implies that the expected profitability of a transaction is likely to decrease more than for an experienced seller. Second, as *Darknet* entrepreneurs face a threat of detection, they will only continue operating if the expected profits exceed the expected punishment and the opportunity cost of the second best option. An entrepreneur with few prior transactions will likely be closer to the minimum revenue needed to continue operations, so that exiting the market may become more likely. We thus expect that for inexperienced entrepreneurs, negative feedback will result in a reduced level of activity or even exit. This in line also with previous literature (Wennberg et al., 2016) that have found that younger and small ventures are more likely to exit when close to the survival reference point. We split this into two hypotheses regarding the expansion or contraction of current activities and the exit from the market altogether:

Hypothesis 1a: Inexperienced entrepreneurs will respond to negative feedback by reducing their scope of operations.

Hypothesis 1b: Inexperienced entrepreneurs will respond to negative feedback

by exiting the market with a higher likelihood.

Entrepreneurs with a higher volume of prior transactions will see their incentives changed in different ways. First, negative feedback will lower the average rating by less than for an inexperienced entrepreneurs with the same average rating. Second, negative feedback is unlikely to push an experienced entrepreneur below the threshold value for the second best alternative. Moreover, an entrepreneur with many prior transactions is likely “in it for the long haul”, so that she thinks more about long-term strategies to rebuild reputation rather than short-term strategies to salvage what is left of the business. Hence, negative feedback is unlikely to affect the probability of exit, but it is interesting to delve deeper into the role of negative feedback on the incentives to adjust one’s level of activities. If an entrepreneur has gathered ample prior experience, she is in a position to withstand negative feedback, so the response will focus on establishing the long-term profitability of the entrepreneur’s operations. Given that is the main motivation, negative feedback for a product in a particular category can trigger “problemistic search” because it is a signal that current operations are not as profitable anymore. Problemistic search involves moving away from current operations and target new products or categories. Moreover, expanding the scope of operations is likely to reduce the attention paid by consumers on a negative experience in a particular category of products. Hence, we expect that following negative feedback, experienced entrepreneurs will be more likely to expand their operations, which we summarize in our second hypothesis:

Hypothesis 2: Experienced entrepreneurs will respond to negative feedback by expanding their scope of operations.

We test these hypotheses in the context of one of the major anonymous marketplaces for illegal goods, *Agora*. It operates on the *Darknet*, which, as we outlined above, is a very useful testing ground for reputation-related strategies because there are few other mechanisms to discipline actors operating on it, and

reputation constitutes one of the key assets in anonymous online markets.

5. Data

The *Agora* marketplace was launched in December 2013 and stopped operations in August 2015 by voluntarily exiting the market due to safety concerns. It was one of the three biggest online marketplaces during that period with *Silk Road 2* and *Evolution* (Soska and Christin, 2015). We focus on *Agora* because *Silk Road 2* was shut down after a law enforcement operation (Operation Onymous) by US and European agencies, and *Evolution* exited the market in a scam withholding more than \$12 million (Bhaskar et al., 2017).

The data used in this analysis were scraped by (Gwern et al., 2015) and made publicly available via *archive.org*. These data include the html source files of ~ 90 anonymous marketplaces covering the period between 2013 and 2015. We parsed those html files to collect the raw data used in this paper. We focus only on the drugs category, which accounts for $\sim 75\%$ of total listings of the marketplace. This lets us compare more homogeneous products and consequently more similar entrepreneurs. We end up with ~ 6.1 million feedbacks for $\sim 1,600$ entrepreneurs (out of the total $\sim 2,900$ entrepreneurs that participate in *Agora*) for 79 weeks from December 2013 until July 2015, covering almost the entire lifespan of *Agora*. We exclude the weeks of *Silk Road 2*'s and *Evolution*'s shutdown so as to not introduce extraneous noise in the data.

Due to general technical reasons (i.e. Tor connection errors) and reasons specific to *Agora* (availability of the website) we lost some observations. However, as these dropped observations were at random times we assume the listings to be i.i.d. observations (Armona, 2017).

5.1. Variables

5.1.1. Dependent Variables

Our hypotheses suggest a relationship between negative feedback and an entrepreneur's level of activity. First, a *Darknet* entrepreneur can reduce activity

drastically by exiting the market altogether. Second, an entrepreneur can modify her portfolio of products offered. For example, an entrepreneur previously selling different types of Marihuana can branch out to offer Cocaine as well, or she can focus on the best-selling (or most profitable) types of Marihuana. We capture the activity level in two ways.

Exit. Our first dependent variable captures the *exit* of an entrepreneurs. We code this as a dummy variable with value one if a given week is the last active week of a given entrepreneur.²

Listings Growth. Our second dependent variable captures the *changes in products' portfolio*. We operationalize this as the growth rate of listings offered by an entrepreneur per week. It is the percentage change of the number of illicit drug products an entrepreneur is offering in week t compared to week $t - 1$.

5.1.2. Independent Variables

Negative Ratio. Our main independent variable is the negative feedback an entrepreneurs receives in a particular week. We code this as the share of negative feedbacks of total feedbacks an entrepreneur received in a given week. Since the mean rating per week of all entrepreneurs included in the sample is 4.89 and 97.38% of the feedback ratings are 5 (which is the maximum), we define as negative feedback any feedback with rating less than 5. We use the natural log of the *Negative Ratio* to account for the magnitude of impact that each negative feedback has. Cabral and Hortaçsu (2010) showed that subsequent negative feedbacks do not have as much impact as the first one.

Transactions Experience. To capture the role of an entrepreneur's transactions experience, we construct a measure of the entrepreneur's prior transactions.

²Note that we cannot rule out the possibility of an entrepreneur deactivating her current account and re-registering under a new name. As we are especially interested in the interaction between an entrepreneur's reputation and strategic responses, this does not bias our results since entrepreneurs giving up their current pseudonym will abandon their accumulated reputation, which is what we intend to capture with the exit variable.

We operationalize this as the number of cumulative reviews an entrepreneur has received before week t . To rate an entrepreneur, a customer must have placed an order. Although not all buyers rate entrepreneurs, the propensity of buyers rating an individual transaction is expected to be constant. Hence, the number of reviews is a useful proxy for the number of transactions and we measure transactions experience as the (log) number of transactions performed.

5.1.3. Control Variables

As control variables we used the time (in weeks) an entrepreneurs is active on *Agora* (*Platform Tenure*) and *Listings* which is the number of different drug products offered by each entrepreneurs at week t . This might include same drugs but packaged differently (for example 0.5g or 1g packs of Cocaine are considered different listings in our definition). While Platform Tenure is highly correlated with Transactions Experience (0.575) and the number of listing is also correlated, albeit somewhat less strongly (0.197), it is important to control for these variables to isolate the effect of the transactions experience, which we consider an alternative indicator of entrepreneurial quality. To consider a counterfactual, if the time a registration was active was considered an indicator of quality, a “sleeping account” that does not sell anything, but is left active, would steadily grow in reputation. Similarly, if portfolio size was an indicator for imputed quality, entrepreneurs could inflate their portfolio size by listing products at inflated prices or canceling transactions to increase their reputation. Hence, while they are correlated to Transaction Experience, they do not proxy for our construct of interest. We also include week and entrepreneur fixed effects to control for unobserved heterogeneity.

6. Results

6.1. Descriptive Statistics

Table 1 gives some summary statistics. The mean negative ratio in week $t - 1$ is 0.029, meaning that 2.9% of the feedbacks an entrepreneur receives are

negatives. As already discussed in Section 5, negative feedback is very rare, so that the impact of negative feedback is all the more important for influencing decisions. We also observe high variance in the number of transactions, demonstrating that the entrepreneurs base on *Agora* is highly heterogeneous in their popularity and experience.

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
$\ln(\text{Negative Ratio}_{t-1})$	32,040	0.0287	0.0877	0	0.693
$\ln(\text{Transactions Experience}_{t-1})$	32,040	7.419	1.904	0	11.31
Exit_t	32,841	0.00384	0.0618	0	1
React_t	33,277	0.682	0.466	0	1
Listings Growth_t	31,840	1.039	7.267	-0.998	612
Listings_{t-1}	31,840	19.13	35.41	1	614
$\text{Platform Tenure}_{t-1}$	31,840	27.30	18.95	1	78

Table 1: Summary Statistics

Table 2 gives pairwise correlations between our variables. As we can see, only Platform Tenure in week $t - 1$ is highly positively correlated (0.575) with Transactions Experience in week $t - 1$. The remaining correlations between variables are fairly moderate.

Variables	$\ln(\text{Negative Ratio}_{t-1})$	$\ln(\text{Transactions Experience}_{t-1})$	Platform Tenure $_{t-1}$	Listings $_{t-1}$	Exit $_t$	React $_t$	Listings Growth $_t$
$\ln(\text{Negative Ratio}_{t-1})$	1.000						
$\ln(\text{Transactions Experience}_{t-1})$	0.002	1.000					
Platform Tenure $_{t-1}$	-0.006	0.575	1.000				
Listings $_{t-1}$	0.025	0.197	0.117	1.000			
Exit $_t$	0.033	-0.034	-0.013	0.005	1.000		
React $_t$	-0.008	-0.002	-0.050	0.039	-0.008	1.000	
Listings Growth $_t$	0.017	0.012	-0.021	-0.075	-0.004	0.098	1.000

Table 2: Cross-correlation table

6.2. Econometric Results

6.2.1. Do entrepreneurs exit the market in response to negative feedback?

Bhaskar et al. (2017) show that negative feedback in anonymous marketplaces increases the probability of an entrepreneur exiting a market. However, the average feedback rating is not the only signal a buyer takes into account when evaluating a product/entrepreneur. Buyers may update their beliefs on the quality of an entrepreneurs taking also into account how experienced an entrepreneur is (e.g. how long or short her history of transactions is). What is the effect of the transactions experience on the impact of negative feedback on exiting the market? Do experienced entrepreneurs leave the market at the same rate as less experienced ones in response to negative feedback? We use the following econometric model to address these questions. Results are in Table 3.

$$\begin{aligned} Pr(Exit_{it} = 1) = & \Phi(\beta_0 + \beta_1 \ln(Negative\ Ratio_{it-1}) + \\ & \beta_2 \ln(Transactions\ Experience_{it-1}) + \beta_3 Platform\ Tenure_{it-1} + \\ & \beta_4 Listings_{it-1} + \varepsilon_{it}), \end{aligned}$$

where Φ is the cumulative normal distribution. $Pr(Exit_{it})$ is the probability of an entrepreneur i to exit *Agora* at time t . $Negative\ Ratio_{it-1}$ is the ratio of Negative Feedback an entrepreneur i has received at time $t - 1$. $Transactions\ Experience_{it-1}$ indicates the number of cumulative transactions an entrepreneur i has performed until the moment $t - 1$. $Platform\ Tenure_{it-1}$ is the number of active weeks in *Agora* of entrepreneur i at time $t - 1$, and $Listings_{it-1}$ is the number of listings entrepreneur i is offering at time $t - 1$. The error term ε_{it} has the standard assumptions, we report robust estimates clustered at the entrepreneur level.

Column (1) in Table 3 includes just the control variables. In column (2) of the same Table we confirm Bhaskar et al. (2017)'s result. In column (3) we test the standalone effect of $Transactions\ Experience_{t-1}$. Finally, in column (4) we include the interaction $Negative\ Ratio_{t-1} \times Transactions\ Experience_{t-1}$ to

identify the effect of the transactions experience of an entrepreneur has on the impact of negative feedback on exiting the market. We find that while the direct effect of negative feedback is positive, so that entrepreneurs with a high share of negative feedbacks are more likely to exit the market, the interaction between the negative ratio and transactions experience is negative, suggesting that the effect weakens for entrepreneurs with high transactions experience.

VARIABLES	(1) Exit _t	(2) Exit _t	(3) Exit _t	(4) Exit _t
ln(Negative Ratio _{t-1})		1.092*** (0.166)		2.311*** (0.510)
ln(Transactions Experience _{t-1})			-0.109*** (0.014)	-0.096*** (0.015)
ln(Negative Ratio _{t-1}) × ln(Transactions Experience _{t-1})				-0.213*** (0.080)
Platform Tenure _{t-1}	-0.004* (0.002)	-0.004* (0.002)	0.003* (0.002)	0.003* (0.002)
Listings _{t-1}	0.001* (0.000)	0.001 (0.000)	0.001*** (0.001)	0.001*** (0.000)
Constant	-2.577*** (0.057)	-2.629*** (0.057)	-1.999*** (0.094)	-2.124*** (0.097)
Observations	30,182	30,182	30,182	30,182
Number of Sellers	1,582	1,582	1,582	1,582

Standard errors clustered at the Seller level in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Table 3: Probability of Exit based on Negative Feedback

Note that the coefficients reported in Table 3 are the ones of the probit model. To understand the magnitude of the effect of the number of prior transactions we plot the marginal effects of negative feedback in Figure 1 (Greene, 2010). For very experienced entrepreneurs, negative feedback has no effect on their probability of exiting the market as the confidence intervals include the null effect. Conversely, entrepreneurs with a small number of prior transactions are more “vulnerable” to the effects of negative feedback. For entrepreneurs with minimum prior experience, a one percent increase in the ratio of negative

feedback increases the probability of exit by 14.6 percentage points. This supports our *Hypothesis 1b* suggesting that inexperienced entrepreneurs are more likely to leave the market upon receiving negative feedback.

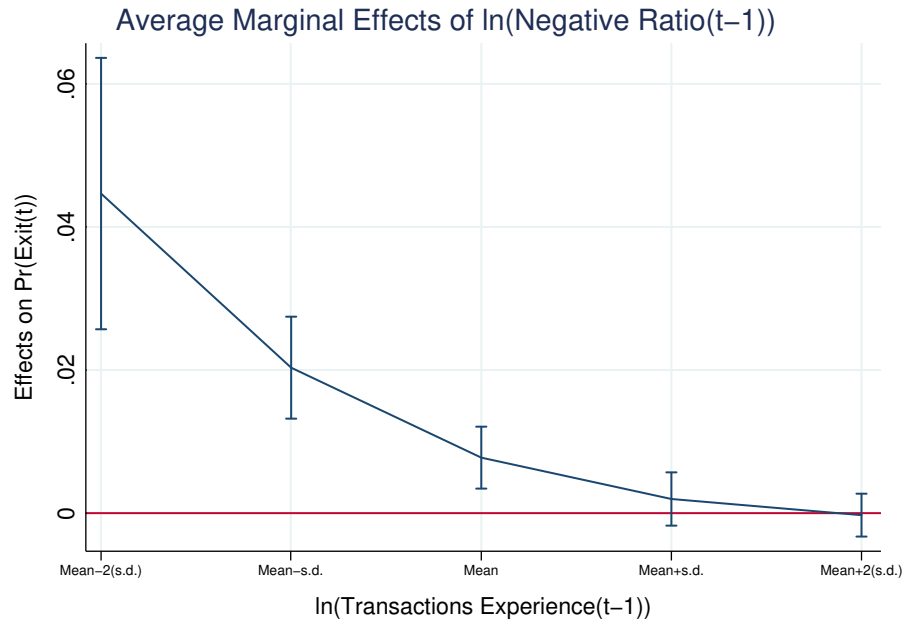


Figure 1: Effect of Negative Feedback on the probability of exiting Agora

6.2.2. How do entrepreneurs adjust their portfolio in response to negative feedback?

In the previous subsection we found that while negative feedback does not affect experienced entrepreneurs' propensity to exit the market, it does make it more likely that inexperienced entrepreneurs exit. However, reaction to negative feedback may also take a more nuanced form of adjustment. Thus, conditional on remaining in the market (the extensive margin), what adjustments in an entrepreneur's product portfolio will be triggered by negative feedback? Hence, to understand adjustments at the intensive margin, we study the effect of negative feedback on the growth rate of the listings each entrepreneurs is offering per week. We use a linear model and report the results in Table 4.

$$\begin{aligned}
ListingsGrowth_{it} = & \beta_0 + \beta_1 \ln(Negative\ Ratio_{it-1}) + \\
& \beta_2 \ln(Transactions\ Experience_{it-1}) + \beta_3 Platform\ Tenure_{it-1} + \\
& \beta_4 Listings_{it-1} + \nu_t + \mu_i + \text{varepsilon}_{it},
\end{aligned}$$

where $Listings\ Growth_{it}$ is the listings growth rate of entrepreneur i at time $t - 1$. This model specification further includes time fixed effects ν_t and entrepreneur fixed effects μ_i . The rest of the model specification remains the same as in previous subsection. As mentioned above, we exclude observations where entrepreneurs decide to exit the market and hence do not change their product portfolio in other ways.

Column (1) of Table 4 again gives the baseline regression only with our control variables. In column (2) of Table 4 we observe a positive effect of negative feedback on listings growth, meaning that entrepreneurs experiencing negative feedback do react by increasing their product portfolio. In column (3), we test the standalone effect of $Transactions\ Experience_{it-1}$. When we include the interaction $Negative\ Ratio_{it-1} \times Transactions\ Experience_{it-1}$ in Column (4), we observe that the main effect switches signs and becomes statistically insignificant, while the interaction term between the negative ratio and transactions experience is positive and significant at the 10 percent level. This suggests that experienced entrepreneurs react to negative feedback by expanding their listings, while inexperienced entrepreneurs do not react by changing their portfolio. This lends support to *Hypothesis 2*, which posits that experienced entrepreneurs will respond to negative feedback by expanding their portfolio. However, the insignificant linear effect of negative feedback (which reflects the reaction of an entrepreneur with no transaction experience) does not confirm *Hypothesis 1a*, which suggests that inexperienced entrepreneurs react to negative feedback by contracting their portfolio. In our data, this does not seem to be the case.

VARIABLES	(1) Listings Growth _t	(2) Listings Growth _t	(3) Listings Growth _t	(4) Listings Growth _t
ln(Negative Ratio _{t-1})		1.051** (0.457)		-1.943 (1.497)
ln(Transactions Experience _{t-1})			0.456*** (0.095)	0.445*** (0.095)
ln(Negative Ratio _{t-1}) × ln(Transactions Experience _{t-1})				0.403* (0.237)
Platform Tenure _{t-1}	0.110*** (0.021)	0.112*** (0.022)	0.102*** (0.020)	0.103*** (0.021)
Listings _{t-1}	-0.163*** (0.032)	-0.163*** (0.032)	-0.165*** (0.032)	-0.164*** (0.032)
Constant	4.004*** (0.712)	4.028*** (0.712)	2.632*** (0.560)	2.699*** (0.560)
Observations	30,062	30,062	30,062	30,062
R ²	0.305	0.305	0.306	0.307
Seller FE	YES	YES	YES	YES
Week FE	YES	YES	YES	YES

Robust standard errors clustered at the Seller level in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Table 4: Listings Growth and Negative Feedback

To get some more intuition on the results of Table 4, we plotted the marginal effect of negative feedback on listings growth by taking into account the number of prior transactions. We observe clearly that entrepreneurs with a few prior transactions pursue a completely different strategy from entrepreneurs with a lot of prior transactions.

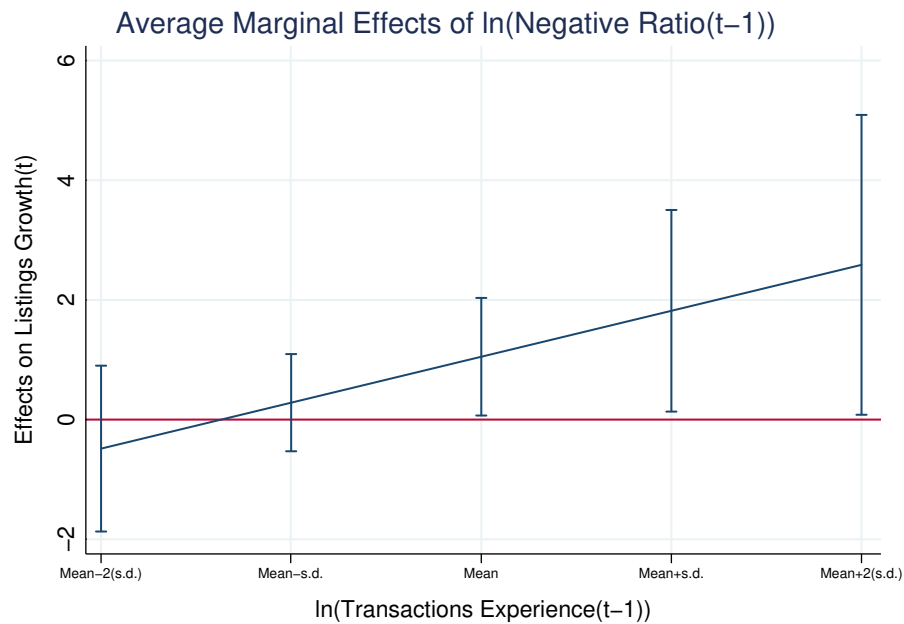


Figure 2: Effect of Negative Feedback on the Listings Growth

In Table 5 we summarize our findings of reactions in response to negative feedback. Inexperienced entrepreneurs are more likely to leave and adjust their activities at the extensive margin, while experienced entrepreneurs expand their offerings on average, i.e. modify at the internal margin. This is discussed in more detail in the next section.

	Inexperienced Entrepreneurs	Experienced Entrepreneurs
Exit	+	0
Expansion	0	+

Table 5: Summary Results

7. Discussion and Conclusion

Our empirical results partly confirm our theoretical predictions: Both experienced and inexperienced *Darknet* entrepreneurs react to negative feedback, but in different ways: Inexperienced entrepreneurs are more likely to exit the market, presumably because they do not expect to be able to continue operating profitably. This is in line with our predictions. However, for those who remain in the market, negative feedback unexpectedly does not trigger either an expansion or contraction of their operations, i.e. the number of products they offer. This behavior may be due to the fact that inexperienced entrepreneurs are closer to their reservation income from selling illegal drugs online and they cannot sustain a prolonged period of less profitable operations. However, if they do continue to operate, they probably lack the resources to expand their listings, but shrinking it brings them closer to the brink of bankruptcy, which again is not desirable. Hence, while inexperienced entrepreneurs might want to expand, their lack of resources does not let them. Hence, their margin of adjustment is the extensive margin, i.e. the decision to operate at all or not. Further adjustments to the intensive margin may only become possible with a longer history of transactions and therefore increased resources.

For experienced entrepreneurs, the reaction to negative feedback differs markedly. Specifically, experienced entrepreneurs do not respond to negative feedback with a higher probability of exit. This is likely due to the fact that an experienced entrepreneur still perceives its long history of transactions as a valuable asset (and basically the only characteristics that sets her noticeably apart from newcomers), so the prospect of giving it up either by leaving the market or by re-registering under a new pseudonym (and no history) appears unattractive.

However, negative feedback does trigger an experienced *Darknet* entrepreneur to expand its listing, in essence growing its portfolio. As we argue, this can be due to problemistic search and the indication that current activities are not particularly successful. Interestingly, in contrast to inexperienced entrepreneurs this puts the focus of adjustment at the intensive margin and not the extensive margin.

This paper contributes to a number of literature streams. First, it is one of the first studies to investigate the managerial responses of a particular breed of digital entrepreneurs, *Darknet* entrepreneurs dealing with illicit goods, drugs in our case. We show that their behavior in response to negative shock follows predictable patterns and that their strategies seem surprisingly sophisticated because they are conditioned on the value of the other reputational resource, the transactions experience. In addition to we contribute to a stream of literature that studies “illegitimate” entrepreneurship (Levitt and Venkatesh, 2000; Webb et al., 2009; Fairlie, 2002). Second, we contribute to the literature on online reputation systems by showing that reputation systems also, and probably especially, work in anonymous marketplaces. This confirms the notion that some markets can self-regulate even in the absence of formal and enforceable contracts simply by operating with a functioning reputation system. Finally, we also contribute to the vast field of behavior in response to performance feedback, i.e. the behavioral theory of the firm (Greve et al., 2003; Greve, 2007; March, 1988). To our knowledge, this is one of the first studies that shows that reactions can differ significantly conditional on the value of assets (reputational in our empirical setting). Specifically, we posit, and find, that transactions experience may cause an entrepreneur’s reaction to flip completely from leaving the market with a higher likelihood (for inexperienced entrepreneurs) to expanding current operations (for experienced entrepreneurs). Our finding of a strong dependency of behavioral reactions to negative feedback to an entrepreneur’s history is a novel contribution to the literature.

Our results also have managerial and policy implications. From a managerial perspective, our results shed light on the role of reputation on online

marketplaces. Also, since the transactions experience seems to matter greatly for buyers' decision-making and in turn for entrepreneurs' responses to an adverse shock, this information should be presented clearly to potential buyers. This also has implications for the design of online marketplaces, and managers should be aware of how this information can play a role in buyers' trust towards the marketplace in general. For policymakers and law enforcement authorities, our study uncovers some of the mechanisms at play in illegal online marketplaces. Clearly, this information is crucial when devising policies on how to intervene in these marketplaces with the goal of reducing their influence or even shutting them down. An interesting conclusion emerges from the strategic response of inexperienced sellers to negative feedback: Given they are more likely to exit following negative feedback, one way to depopulate an illegal marketplace would be to systematically issue negative feedback to induce seller exit. If the marketplace is still relatively young, most sellers will be inexperienced, so this could help stunt growth of emerging marketplaces. The downside might be that experienced sellers become more powerful because they expand their product offerings in response, leading to market concentration and larger sellers of illegal goods and services.

Finally, our study is not without limitations. First, our data do not let us observe entrepreneurs' post-exit behavior, which could capture multiple activities like "going legal", selling drugs offline, or re-registering under a different pseudonym to sell the same goods. This introduces some noise in our data, but we do not believe that it biases our results. Second, while our setting of anonymous online marketplaces is somewhat unique, we believe our results translate well to other online marketplaces, as long as reputation and an entrepreneur's history are important drivers of buyer behavior. Finally, while our data is quite detailed and even captures transaction-level characteristics, we do not, somewhat inherent to the (illicit) markets we study, learn much about other characteristics of the entrepreneurs. We do believe, however, that this reflects the situation in a fairly large share of internet marketplaces. We are aware, however, that our study is a first attempt at capturing some of the rich dynam-

ics in a growing part of the economy. We hope our work will inspire researchers to study related aspects in *Darknet* markets in the future.

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