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Complex dynamics of buyers and sellers in dark web markets

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Extended Abstract

Dark web marketplaces are unregulated online platforms that facilitate the trade of illicit goods among users. By operating outside the law and trading illegal products, they affect several layers of diverse social system structures. The most representative category of traded products are drugs, followed by stolen bank information, credit cards, fake IDs, guns, and also products related to ongoing events in our society. For instance, during the COVID-19 pandemic, as a result of the health issue, economic fear, and a misinformation-driven panic, a spike in the trading of chloroquine, COVID vaccines, fake vaccines, and fake vaccination certificates was observed in dark web marketplaces [1].

Due to their illegal nature, dark markets exhibit unique dynamics not found in typical marketplaces. Users are offered anonymity, but have no protection from the dark markets. Despite closures from authorities or exit scams, the ecosystem continued to grow and has shown resilience as new markets are created and users migrate – resulting in a dynamics metaphorically called a game of 'Whack-a-Mole' [2]. This resilience has been typically observed through global measures, such as traded volume or number of users.

By developing a method to classify users either as sellers or buyers, we were able to uncover unseen complex dynamics emerging from the networks of transaction among those parties. We analysed the evolution of the dark market ecosystem over more than a decade. Our results are based on the temporal networks of the 32 largest dark markets by volume and the associated peer-to-peer (P2P) network of transactions between the users. We showed that the network of sellers is composed mostly by sellers that trade only in the P2P network, although most buyers trade only in markets. In particular, we analysed the dynamics of 'multihomers', defined as users that are simultaneously trading in more than one market. By identifying sellers and buyers from all traders, we could identify 'multisellers' (i.e., a multihomers that are sellers) and 'multibuyers' (i.e., multihomers that are buyers). We found that the dynamics of multihomers has a central role in the connectivity of the ecosystem. Moreover, by studying the effects of external shocks, we observed that the ecosystem resilience is mostly supported by the network of buyers rather than sellers.

The major shock on the ecosystem was caused by a law enforcement operation by the end of 2017. The traded volume of the markets notably drops afterwards but rapidly recovers previous values and continues to grow. However, we show in the first row of Fig. 1 that the multiseller network, where nodes are active markets and edges are multisellers, suffered a structural change after the operation. Nevertheless, we found that the median net income of multisellers was persistently larger than that of non-multisellers throughout the whole period of observation, as shown in Fig. 2. Conversely, the network of multibuyers exhibited a strong resilience with almost imperceptible changes, as show in the second row of Fig. 1. We observed an intermediate resilience regime in the seller-to-seller (S2S) network, the network of transactions between sellers, as shown in the third row of Fig. 1. Although the S2S network also suffers a

structural change, unlike the multiseller network, it shows signs of recovery but slower than the multibuyer network.

These findings unveil complex patterns beneath the temporal networks of transactions in dark web marketplaces and its associated P2P network. By studying the networks and the dynamics of buyers and sellers, we characterize the resilience and evolution of the ecosystem of dark web markets.

References

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[2] ElBahrawy, A., Alessandretti, L., Rusnac, L., Goldsmith, D., Teytelboym, A., and Baronchelli, A. Collective dynamics of dark web marketplaces. *Sci Rep*, 10(1), 1-8, 2020.

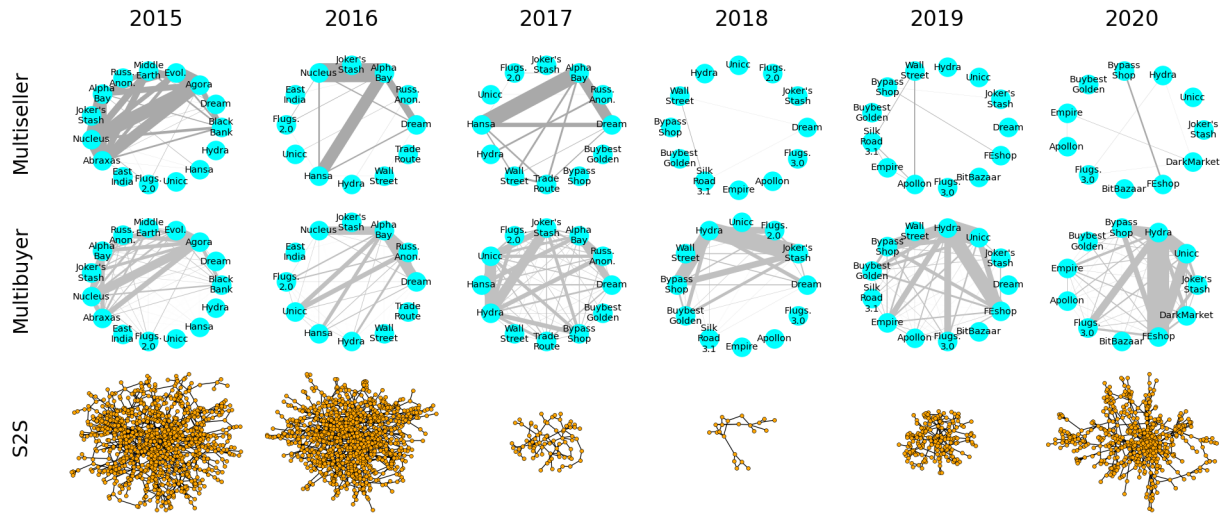

Figure 1: **Three different regimes of resilience.** The evolution of the multiseller network in the first row, the multibuyer network in the second row, and the giant component of the seller-to-seller (S2S) network in the third row for each year from 2015 to 2020. In the multiseller (multibuyer) network, nodes are active markets in that year, edges are mulitsellers (multibuyers), and the width of the edges is proportional to their number. In the S2S network, nodes are active sellers in that year and there is an edge between two nodes if at least one transaction occurred between them during that year.

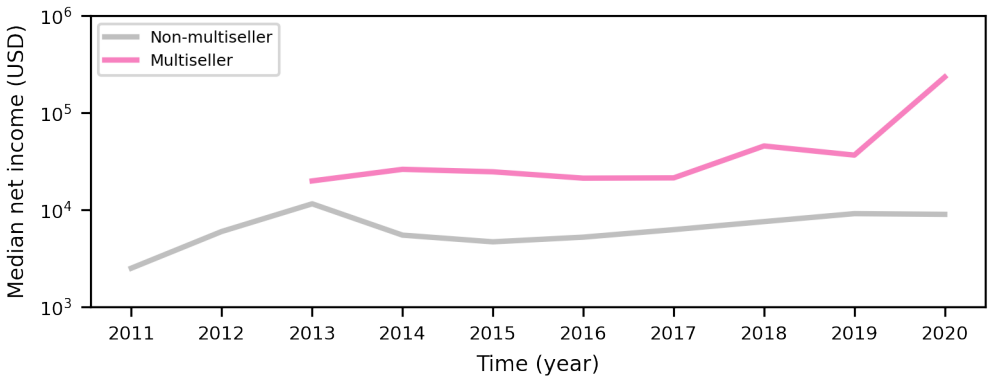

Figure 2: **The multihoming activity yields a higher income for sellers.** The yearly net income of multisellers is typically larger than that of sellers that are not multihomers (non-multisellers), throughout the whole period of observation.