Emergence, survival and segregation of competing gangs

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In this work, we approach the phenomenon of criminal activity from an infectious perspective by using compartmental agent-based models, building on a recently introduced kinetic model [1, 2] on the dynamics of norm violating (corrupt) behavior. Specifically, we focus on addressing how the existence of two competing gangs shapes the penetration of crime in society. The model, named HCCO because of their compartments' names (see Figure 1a), features a unique mechanism inherent to the social process of delation, by which the recovery of Corrupt (infected) agents is mediated by interaction with their Honest (susceptible) neighbors, reaching an Ostracism (recovered) state. Moreover, we consider that both gangs openly compete (delate each other).

The mean-field analysis of the model reveals the existence of different equilibria as a function of the delation mechanism of the honest population. While non-selective delation always leads to the extinction of the minority gang, the introduction of selective delation, reducing the probability that honest agents delate the minority gang, leads to a coexistence regime. As a result of the inter-gang delation events, the latter choice turns into a convenient strategy, resulting in a lower penetration of crime than in the former scenario.

However, the implementation of the model in networked populations with homogeneous contact patterns, both by Markov equations and Monte Carlo simulations, reveals that the evolution of crime substantially differs from that predicted by the mean-field equations (see Figure 1b). We find that the system evolves towards segregated configurations between gangs where agents' surroundings deviate from the well-mixed scenario. Moreover, in networks with spatial structure, this segregation plays a major role, leading to the emergence of two disjoint macroscopic clusters of criminals, each one associated with a gang, as seen in Figure 2. The size of these clusters, quantified with the inter-gang distances, is large enough to impair the cross-delation events resulting in a higher penetration of crime in the population, and thus explaining the important differences found with respect to the mean-field predictions.

In general terms, our analysis reveals that the interplay of the network structure, the competition between spreading units (criminal gangs) and the strategy chosen to control their diffusion (delation mechanism) crucially shapes the outcome of the dynamics. Our framework constitutes the first steps towards a formal characterization of the evolution of crime via compartmental models. In this sense, we think that this model lays the foundation for the ellaboration of a more complete formalism including more realistic features inherent to corruption such as the lack of reinsertion of certain individuals and social stigma.

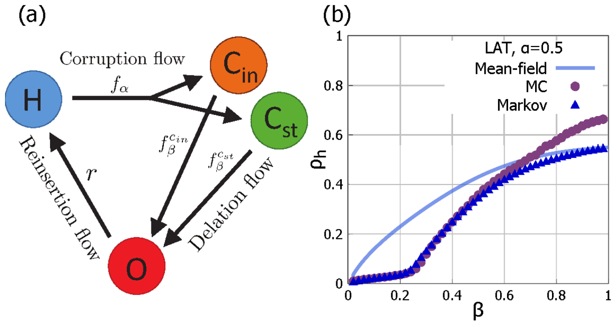

Fig. 1. (a) Compartmental scheme and flows of the HCCO model. (b) Fraction of honest population in a lattice in the gang coexistence situation, for $r = 0.5$ and corruption probability $\alpha = 0.5$, as a function of the delation probability β. We compare the mean-field, Markov and Monte Carlo (agent based) simulations. Substantial differences between the three scenarios can be seen.

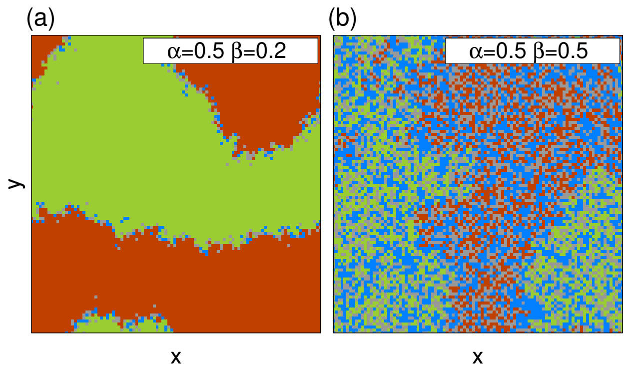

Fig. 2. Lattice configurations corresponding to Monte Carlo simulations of the HCCO model. The four species are shown: Honest (blue), C_{in} gang (green), C_{st} gang (orange) and Ostracism (grey), and segregation between both corrupt species can be clearly seen. Configurations correspond to $\alpha = 0.5$, $\beta = 0.2$ (a) and $\alpha = 0.5$, $\beta = 0.5$ (b).

[1] D. Lu, F. Bauzá, D. Soriano-Paños, J. Gómez-Gardeñes and L.M. Floría, Phys. Rev. E **101**, 022306 (2020).

[2] F. Bauzá, D. Soriano-Paños, J. Gómez-Gardeñes, and L.M. Floría, Chaos **30**, 063107 (2020).