# Network Security and Contagion

[Invited talk]

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## ABSTRACT

This paper develops a theoretical model of investments in security in a network of interconnected agents. The network connections introduce the possibility of cascading failures depending on exogenous or endogenous attacks and the profile of security investments by the agents. The general presumption in the literature, based on intuitive arguments or analysis of symmetric networks, is that because security investments create positive externalities on other agents, there will be underinvestment in security. We show that this reasoning is incomplete because of a first-order economic force: security investments are also strategic substitutes. In a general (non-symmetric) network, this implies that underinvestment by some agents will encourage overinvestment by others. We demonstrate by means of examples that not only there will be overinvestment by some agents but also aggregate probabilities of infection can be lower in equilibrium than in the social optimum. We then provide sufficient conditions for underinvestment. This requires both sufficiently convex cost functions (just convexity is not enough) and networks that are either symmetric or locally tree-like (i.e., either trees or in the case of stochastic networks, without local cycles with high probability). We also characterize the impact of network structure on equilibrium and optimal investments. Finally, we show that when the attack location is endogenized (by assuming that the attacker chooses a probability distribution over the location of the attack in order to maximize damage), there is another reason for overinvestment: greater investment by an agent shifts the attack to other parts of the network.

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