On Global Games of Regime Change in Networks

M. Dahleh, A. Tahbaz-Salehi, J. Tsitsiklis, and S. Zoumpoulis*

Global games of status quo subversion — coordination games of incomplete information in which a status quo is abandoned once a sufficiently large fraction of agents attacks it — have been used as stylized models of crisis phenomena such as currency attacks, debt crises, bank runs, and political change. To the best of our knowledge, all existing applications of such games to crises assume a continuum of agents and a private (and possibly, in addition, a public) noisy signal of the fundamentals for each agent (there are no complex patterns of communication among the agents). In this work, we propose a model involving a *discrete* number of agents, interconnected through an underlying *network*. We seek to answer the question of how the outcomes depend on the topology of the social network.

We study a game of regime change with a finite number of agents, in which each agent receives and shares noisy signals concerning the strength of the status quo (i.e., the fundamentals) according to her position in a social network. She can then either attack the status quo or not attack. Attacking can net a positive or negative payoff and is thus a risky action. Not attacking nets 0 payoff and is thus a safe action. Our payoff model exhibits strategic complementarities and state monotonicity: a player's incentive to play the risky action is weakly higher the more opponents coordinate on the risky action, and strictly higher the weaker the fundamentals are.

Our game admits a variety of interpretations and applications, in all of which beliefs have the same self-fulfilling nature. Prominent examples are currency attacks (when a large speculative attack forces the central bank to abandon the peg), bank runs (when a large number of bank customers withdraw their deposits because they believe the bank is, or might become, insolvent), debt crises (when a country/company fails to coordinate its creditors to roll over its debt and is hence forced into bankruptcy), and political protests (when a large number of citizens decide whether or not to take actions to subvert a repressive dictator or some other political establishment).

We model the exchange of idiosyncratic noisy signals about the fundamentals with a link in a graph that represents the social network. We identify the social network topology as the determining factor with respect to the dichotomy between multiplicity and uniqueness of equilibria, and pose the following question: what are necessary and sufficient conditions on the social network topology for uniqueness? The question of uniqueness versus multiplicity is intertwined with the question of predictability of outcomes, as well as the question of amenability of the model to policy implications through comparative statics analyses. We seek to quantify the connection between the topology of the social network and the predictability of individual behavior in large networks, as well as the connection between the topology of the social network and individual attitudes towards risk.

In a network consisting of finitely many disconnected agents, there is a unique strategy profile that survives iterated elimination of strictly dominated strategies, and therefore a unique Bayesian Nash equilibrium; in sharp contrast, introducing a single link between any two agents induces multiplicity. We first study networks that are unions of disconnected cliques and provide a characterization of strategies that survive iterated elimination of strictly dominated strategies (IESDS). We prove that for each agent, all the information about the strength of the status quo can be summarized in a one-dimensional statistic, the average of the observations: in any strategy profile that survives IESDS, each agent chooses the risky action (attack) if the average of her observations is less than a certain threshold, and chooses the safe action (not attack) if the average of her observations is greater than some other threshold; in addition, any strategy profile that satisfies these two conditions survives

*All authors are with the Laboratory of Information and Decision Systems, at MIT. Their emails are {dahleh, alirezat, jnt, szoumpou}@mit.edu.

IESDS. For the special case of cliques of equal size, we provide a characterization involving closed-form analytical expressions. Our analysis proves multiplicity for unions of disconnected (non-trivial) cliques. We also study the case of asymptotically many agents, in which we obtain sufficient conditions on the network topology for asymptotic uniqueness: if each clique grows sublinearly in the number of agents, then we have uniqueness. In contrast, linear growth induces multiplicity. We interpret this result, underlining the trafeoff between predictability and risk-friendly attitude towards uncertainty for the social planner.

In addition to our results for unions of disconnected cliques, we present preliminary results that classify more general networks into a class of networks that induce uniqueness and a class that induce multiplicity of Bayesian Nash equilibria, coming closer to a complete characterization of topological conditions for uniqueness versus multiplicity.

As Angeletos and Werning put it, "it is a love-hate relationship: economists are at once fascinated and uncomfortable with multiple equilibria." In the economic literature, common knowledge of the fundamentals leads to the standard case of multiple equilibria due to the self-fulfilling nature of agents' beliefs. Morris and Shin and others propose that multiplicity vanishes once the economy/society is perturbed away from the complete-information benchmark. We show that perturbation may or may not induce uniqueness in the context of a social network of discrete agents, depending on how the noisy signals are communicated, in other words depending on the topology of the social network.

`web.mit.edu/~szoumpou/Public/NetEcon11WorkingPaper.pdf`