Research Statement

Theodoros Rapanos
Department of Economics, Stockholm University
theodoros.rapanos@ne.su.se

My research interests lie in the field of Microeconomics, with a focus on Economics of Networks and Applied Game Theory. My work studies the effects of incomplete information on economic outcomes, as well as the process of information acquisition and aggregation *per se*. My interest in Economics in genral, and these areas in particular, has been motivated by my belief that incomplete information and suboptimal information acquisition are fundamental sources of inefficiencies in many economic and social phenomena, and a deeper understanding of these areas can help us remedy them. My research in these areas can be summarized in the following two papers.

1 Learning in networks

Acquisition and aggregation of information is a critical part of the decision making process of individuals, firms, and organisations. Access, however, to the primary sources of information is not always feasible. Hence, people often obtain their information through secondary sources, such as friends, colleagues or other contacts, who may have themselves acquired their information indirectly. Social and professional networks play thus a prominent role in the process of information diffusion in a society.

My job market paper, "***What makes an opinion leader: expertise versus popularity***", studies how idiosyncratic and social characteristics of individuals determine their social influence. It builds on an idea that was formalized several decades ago by DeGroot (1974), but only recently introduced into economic modelling, mainly due to the work of DeMarzo et al. (2003) and Golub and Jackson (2010). The main idea underlying their approach is simple and compelling: individuals collect and aggregate information or opinions from their peers by simply taking a weighted average of the information or opinion of their contacts.

Both, however, the main research question of my paper, and the way the learning process is modelled, differ from those in the existing literature. In terms of the questions asked, the focus of my work is not only on *who* is more influential in a given society, but also *why* they are influential. In modelling terms, the key differentiating characteristic is the introduction of the idea that agents adjust the amount of trust they assign to their peers to the flow of information in the network. Hence, they may initially pay little attention to contacts with poor information, but increase it later on, if these contact have in the meantime received information from better informed agents. In the standard DeGroot framework, in contrast, the weights are constant through time, and thus they do not reflect the changes in the information quality of the agents.

The main finding of the paper is that each agent's influence can be decomposed into three components. The first coincides with eigenvector centrality, a well-known measure of *popularity* or *prestige*, and captures the part of an agent's influence that can be attributed to his or her position in the

network. The second is a measure of information precision, and captures the part of an agent's influence that is due to the *information* or the *expertise* he or she possesses. The third one, common for all agents in a given network, is a measure of how information is distorted as it flows through the network. Unless the network structure is complete or symmetric, information originating from the popular agents will be over-weighted, while information from the others will be under-weighted.

This finding not only provides an insight into the origins of social influence, but also has important practical implications. Learning in this model, like in all models that follow the DeGroot paradigm, will be in general suboptimal. This result, in line with empirical findings, suggests that there is room for potentially welfare-enhancing policy intervention. What are, for example, the characteristics of the agents that the social planner should target in order to inform society on the benefits of adopting a new technology, or raise awareness about disease prevention measures? Conversely, which person should be misinformed or isolated in order to disrupt the flow of information in a criminal organisation?

The model proposed here facilitates the social welfare analysis of such policies due to three features. First, social influence is given by a mathematically simple formula, expressed in terms of the "fundamentals" of the model —agents' popularity and expertise— facilitating thus the design and evaluation of targeted policy interventions. Second, as this breakdown implies, the minimal information required for a policy intervention to be carried out efficiently is an (approximate) knowledge of agents' popularity and expertise, at least of the popular or influential ones. Although this requirement is still nontrivial, it is considerably weaker than the corresponding requirement in the standard DeGroot model —an approximate, at least, knowledge of the entire, weighted network structure of the society. Third, the proposed model has nice testable implications: given, for example, the initial distribution of information, it predicts that all remaining network effects should be accounted for by eigenvector centrality.

There are two interesting directions towards which the present model can be extended. First, while people take into account that some of their sources may possess better information than others, or may be in contact with people who do, they also evaluate others' opinions based on subjective criteria, such as personal feelings, ideology, or assessments of a person's trustworthiness. Currently I am working on developing a hybrid model that reconciles these two approaches. This can help us gain a better understanding of how subjective and arbitrary judgements interact with objective factors to shape social influence.

Second, my job market paper takes an asymptotic approach to the above issues. In certain setups, though, convergence may be slow, and a significant amount of time may be required for the limiting predictions to become a good approximation of the short-run dynamics of the model (see, for example, Golub and Jackson, 2012). In a follow-up paper, I use results from linear algebra theory (Anthonisse and Tijms, 1977; Federgruen, 1981) to study the speed of convergence towards the consensus, and examine how this depends on the pattern of information allocation between central and peripheral agents.

2 Social networks under incomplete information

Apart from serving as channels of communication and information transmission, social networks constitute the environment within which people live, socialize and interact with others. Important decisions concerning education, employment, consumption, and leisure have been shown to be affected by one's social environment (Topa and Zenou, 2015). Games on networks have been extensively used as a tool to analyse a wide variety of situations where agents' payoffs, and therefore their behaviour, depend on those of their friends (Jackson and Zenou, 2015).

The majority of this literature builds on an important, albeit implicit assumption: individuals interact and take decisions in a perfectly known environment. In many cases, however, this assumption can be deemed to be quite strong: prospective college students may be aware neither of the benefits of pursuing further education nor of the costs that such a decision would entail; firms choose their investment on innovation in an environment where demand, costs and returns are uncertain.

My second paper, "***Conformism under incomplete information***", co-authored with **Marc Sommer** (University of Zurich) and **Yves Zenou** (Stockholm University), is the first to study the implications of introducing incomplete information in network models with social norms. This issue is of considerable importance, since these models have obtained widespread use in the theoretical, and especially in the empirical literature. Their applications include education (Calvó-Armengol et al., 2009), labour market outcomes (Patacchini and Zenou, 2012), consumption (De Giorgi et al., 2014), and crime (Lindquist and Zenou, 2014).

In a recent paper, Blume et al. (2015) stipulate rigorously the conditions required for econometric identification of such models under incomplete information, for different network configurations, and for a wide range of different possible types of data that may be available to the researcher. Our work can be seen as complementary to theirs, since it aims at filling a different part of the gap that exists in the literature: namely, to provide an economic and game theoretic framework suitable for policy evaluation and welfare analysis.

We model the individuals' decision problem as a Bayesian network game. Agents are heterogeneous, and may have incomplete, and potentially asymmetric information about the value of any one of the basic parameters of the model, such as the private benefit of an activity, its private cost, or society's tolerance towards individuals who deviate from the (endogenously determined) social norm.

We show existence and uniqueness of the Bayes-Nash equilibrium, characterize the agents' optimal decisions, and examine under which conditions policy interventions can be welfare-improving. In particular, we show how changes in the precision of the information that agents possess affect their behaviour, and hence their welfare, and that of their neighbours. We are presently working on identifying the characteristics of the agents to whom a certain amount of additional information should be given in order to maximize social welfare.

As a future path of research, we intend to extend our model in order to account for potentially positive spillovers from social interaction (for example, peer effects in education, see Liu et al., 2014), and study how this affects equilibrium strategies and payoffs.

References

ANTHONISSE, J. M. AND H. TIJMS (1977): "Exponential convergence of products of stochastic matrices," *Journal of Mathematical Analysis and Applications*, 59, 360–364.

BLUME, L. E., W. A. BROCK, S. N. DURLAUF, AND R. JAYARAMAN (2015): "Linear social interactions models," *Journal of Political Economy*, 123, 444–496.

CALVÓ-ARMENGOL, A., E. PATACCHINI, AND Y. ZENOU (2009): "Peer effects and social networks in education," *The Review of Econmic Studies*, 76, 1239–1267.

DE GIORGI, G., A. FREDERIKSEN, AND L. PISTAFERRI (2014): "Consumption network effects," Unpublished manuscript, Stanford University.

DEGROOT, M. H. (1974): "Reaching a consensus," *Journal of the American Statistical Association*, 69, 118–121.

DEMARZO, P. M., D. VAYANOS, AND J. ZWIEBEL (2003): "Persuasion bias, social influence, and unidimensional opinions," *The Quarterly Journal of Economics*, 118, 909–968.

FEDERGRUEN, A. (1981): "The rate of convergence for backwards products of a convergent sequence of finite Markov matrices," *Stochastic Processes and their Applications*, 11, 187–192.

GOLUB, B. AND M. O. JACKSON (2010): "Naïve learning in social networks and the wisdom of crowds," *American Economic Journal: Microeconomics*, 2, 112–149.

——— (2012): "How homophily affects the speed of learning and best-response dynamics," *The Quarterly Journal of Economics*, 127, 1287–1338.

JACKSON, M. O. AND Y. ZENOU (2015): "Games on networks," in *Handbook of Game Theory*, ed. by H. P. Young and S. Zamir, Amsterdam: Elsevier, vol. 4, 91–157.

LINDQUIST, M. J. AND Y. ZENOU (2014): "Key players in co-offending networks," CEPR Discussion Paper No. 9889.

LIU, X., E. PATACCHINI, AND Y. ZENOU (2014): "Endogenous peer effects: local aggregate or local average?" *Journal of Economic Behavior & Organization*, 103, 39–59.

PATACCHINI, E. AND Y. ZENOU (2012): "Ethnic networks and employment outcomes," *Regional Science and Urban Economics*, 42, 938–949.

TOPA, G. AND Y. ZENOU (2015): "Neighborhood and network effects," in *Handbook of Regional and Urban Economics*, ed. by J. V. H. Gilles Duranton and W. C. Strange, Amsterdam: Elsevier, vol. 5, 561–624.