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# Boundedly rational opinion dynamics in social networks: Does indegree matter?

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ABSTRACT

This paper investigates opinion dynamics and social influence in directed communication networks. We study the theoretical properties of a boundedly rational model of opinion formation in which individuals aggregate the information they receive from their neighbors by using weights that are a function of neighbors' indegree. We then present the results of a laboratory experiment explicitly designed to test the causal effect of indegree on social influence. We find that the social influence of an agent is positively affected by the number of individuals she listens to. When forming their opinions, agents take into account the structure of their communication network, although only to a limited extent.


## 1. Introduction

Opinions are an important determinant of economic behavior, as they crucially affect the decisions of individual market participants. But how are opinions formed? Social learning plays a key role for opinion formation. Individuals update their opinions by observing the behavior of others and, above all, by communicating with the individuals they are connected to in their social network, such as family members, friends and colleagues. It is therefore important to understand how the structure of social relationships affects opinion dynamics.[1] This paper provides a theoretical and empirical investigation of boundedly rational opinion formation in social networks.

The economic literature has recently paid increasing attention to opinion dynamics in social networks (see, e.g., Jackson and Yariv, 2010; Acemoglu and Ozdaglar, 2011, for comprehensive reviews). Two main approaches can be identified. A first group of studies focuses on Bayesian updating, under the assumption that agents optimally process the information about the network structure and the probability distribution of the signals observed by other agents (e.g., Gale and Kariv, 2003;

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[1] Understanding opinion dynamics in social networks has become even more relevant with the recent advent of communication technologies, such as Facebook and Twitter, that provide explicit representations of the previously implicit network of connections.

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Acemoglu et al., 2011, 2014). Since Bayesian updating is generally characterized by high computational complexity, even under complete information, a second group of studies focuses on boundedly rational updating rules. These works generally consider simple and plausible protocols for belief updating, investigating the role played by the structure of the social network for the convergence of opinions, the efficient aggregation of information, and the social influence of individual agents.

The most common approach to boundedly rational opinion formation is based on the seminal model by DeGroot (1974), whereby agents update their opinion by taking an average of their neighbors' opinions.[2] This basic framework has been widely adopted and extended, explicitly assuming a communication network and modelling opinions as point estimates rather than probability distributions (e.g., Bala and Goyal, 1998; Golub and Jackson, 2010; Möbius et al., 2010; Jadbabaie et al., 2012; Buechel et al., 2015). In a prominent paper, DeMarzo et al. (2003) start from a general model in which updating weights can differ among neighbors and change over time, to then focus on the case in which individuals place constant and equal weights on all neighbors. In this framework, failing to account for repetitions of information leads to *persuasion bias*: after repeated communication, opinions converge to a consensus that is biased towards the initial beliefs of the most influential (i.e., better connected) individuals.[3] In this setting, agents' social influence depends on their position in the network and, more specifically, on being listened to, directly or indirectly, by many other agents.

In a recent paper, Corazzini et al. (2012) present an experimental investigation of persuasion bias in communication networks.[4] Their results indicate that the structure of the network matters for social influence. More specifically, social influence is found to depend not only on being listened to by many others, consistent with persuasion bias, but also on listening to many others. In order to explain this finding, they propose a generalized boundedly rational updating rule according to which individuals place higher weight on the opinion of neighbors who have more sources of information. In this framework, the social influence of an agent can be positively affected by both her outdegree (the number of outgoing links) *and* her indegree (the number of incoming links), a feature referred to as "*influential listeners*".

It should be observed that Corazzini et al. (2012) proposed their generalized boundedly rational updating rule as an ex post interpretation of the results of an experiment aimed at testing persuasion bias, as predicted by DeMarzo et al. (2003). Since both outgoing and incoming links of the relevant nodes change at the same time, their experiment does not provide a test of a causal indegree effect, but only evidence consistent with it. In addition, despite providing a simple and plausible generalization, the *influential listeners* updating rule was proposed without an explicit characterization of its properties, such as convergence to a consensus (do individuals end up sharing the same opinion?) and efficiency (does such shared opinion optimally aggregate available information?). Therefore, building on Corazzini et al. (2012), the contribution of this paper is twofold.

First, we study theoretically the class of *linear* updating models and, in particular, the model proposed by Corazzini et al. (2012), as a simple generalization of the updating rule in DeMarzo et al. (2003). We obtain some positive and negative results on the feasibility of optimal rules of thumb, and characterize the way in which efficiency depends on the topology of the underlying network. We show that, in balanced networks (i.e., with indegree equal to outdegree for each node), placing higher weight on neighbors with higher indegree is less efficient than placing equal weights on all neighbors. On the other hand, in unbalanced networks it is generally more efficient to place higher weight on neighbors with higher indegree, and there exist networks in which it is optimal to place arbitrarily high weight on agents with higher indegree.

Second, we present a laboratory experiment explicitly designed to test the causal effect of indegree on social influence. The structure of the directed network used in the experiment allows us to manipulate the indegree of the relevant nodes while keeping constant their outdegree, providing a clean test of the causal effect of indegree on opinion formation. Differently from previous experimental works, by comparing the social influence of different nodes we are able to test the null hypothesis that opinions are updated by averaging neighbors' opinions with equal weights, against the alternative that updating weights positively depend on neighbors' indegree. We find strong evidence of a causal indegree effect on opinion formation: the social influence of an agent is positively and significantly affected by the number of individuals she listens to. This is an important finding, as it indicates that, when forming their opinions, agents explicitly take into account the structure of their communication network, although only to a limited extent.

The remainder of the paper is structured as follows. Section 2 presents the theory (technical details are in Appendix A). Section 3 describes the experimental design (experimental instructions are in Appendix B). Section 4 provides the experimental results. Section 5 concludes with a discussion of the key findings.

## 2. Theoretical framework

Following DeMarzo et al. (2003), consider a setting where a set $\mathcal{N} = \{1, \ldots, n\}$ of agents, communicating within a social network, want to estimate some unknown state of the world represented by the parameter $\theta \in \mathbb{R}$. Each agent starts with

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[2] DeGroot (1974) does not explicitly refer to a network environment (as French, 1956, and Harary, 1959, do in their studies on social power, later generalized by Friedkin and Johnsen, 1990), since all agents can communicate with all other agents. However, each individual places given weights on the opinions of others, so that the weights implicitly define a network. These weights, which are constant over time, determine the evolution and possible convergence of opinions.

[3] See DellaVigna and Gentzkow (2010) for a recent survey of the evidence on persuasive communication.

[4] See also Brandts et al. (2014) for a closely related analysis.