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Network formation with heterogeneous players ☆

Andrea Galeotti [a], Sanjeev Goyal [a,*], Jurjen Kamphorst [b]

[a] *Department of Economics, University of Essex*
[b] *Department of Econometrics and Tinbergen Institute, Free University*

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Abstract

This paper extends the connections model of network formation by allowing for players who are heterogeneous with respect to values as well as the costs of forming links. Our principal result is that centrality and short average distances between individuals are robust features of equilibrium networks.
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1. Introduction

The role of social and economic networks in shaping individual behavior and aggregate phenomena has received increasing attention in recent years. This work has been accompanied by research of sociologists, economists and physicists into the character of actual networks. This research shows that communication networks, scientific collaboration net-

☆ This paper subsumes two earlier papers, 'Equilibrium Networks with Heterogeneous Players,' by Galeotti and Goyal (2002) and 'Stable Equilibrium Networks with Heterogeneous Players,' by Galeotti and Kamphorst (2003).

* Corresponding author.
E-mail addresses: agaleo@essex.ac.uk (A. Galeotti), sgoyal@essex.ac.uk (S. Goyal), jjakamphorst@yahoo.co.uk (J. Kamphorst).

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works, social networks and the web exhibit high levels of centrality and small average distances.[1] This widespread stability of centrality and small distances has led researchers to develop theories of network formation which can explain these features.

The connections model proposed in Bala and Goyal (2000a) offers a simple framework for the study of network formation.[2] In this model there is a set of players who each gain from accessing other players. Player 1 can access player 2 directly by forming a link; this link also allows player 1 access to other players that player 2 is accessing on his own. We will suppose that the link formed by 1 with 2 creates a similar flow of benefits to 2.[3] Bala and Goyal (2000a) show that if a player's payoffs are increasing in the number of other players accessed and decreasing in the number of links formed, then an equilibrium network can have only one of two possible structures: it is either a center-sponsored star (a network in which one player, the center, forms links with all the other players) or the empty network (which has no links). We note that a star exhibits high centrality and short distances between individuals. In this paper we examine the impact of ex ante player heterogeneity on these findings.

Ex ante asymmetries arise quite naturally in many contexts. For instance, in the context of information networks it is often the case that some individuals are more interested in particular issues (such as computer software) and therefore better informed which makes them more valuable as contacts. Similarly, individuals differ in communication and social skills. Finally, individuals can often be classified into distinct groups (based on geographical or cultural reasons) and forming links within a group is cheaper as compared to forming links across groups.

We start with a general model of heterogeneous players: the costs to player i of a link with player j as well as the benefits of such a link are allowed to depend on both i and j. In addition, we assume that the length of the path does not matter in defining the benefits (there is no decay). We first consider a particular form of cost heterogeneity: for any player i the costs of forming links with every other player are c_i but we allow this cost to vary across players. In this setting we find that if benefits are homogeneous then a strict equilibrium is either an empty network or a center-sponsored star. By contrast, if values are heterogeneous then partially connected networks can also arise, though each (non-singleton) component constitutes a center-sponsored star (Proposition 3.1). These results

[1] See Rogers and Kincaid (1981) for networks of communication, Goyal et al. (2004) for co-authorship networks in economics and Newman (2001) for co-authorship networks in other subjects, Burt (1992) for work on social networks, Albert and Barabási (2002) for evidence on the architecture of the World Wide Web.

[2] There are two versions of the connections model: the case where individual players can form links unilaterally was introduced in Bala and Goyal (2000a) and Goyal (1993), while the case where links are formed based on bilateral agreement was introduced in Jackson and Wolinsky (1996). The term *connections model* is due to Jackson and Wolinsky (1996). Both the versions have been extensively studied in the literature. Theoretical work on this model includes Bala and Goyal (2000b), Deroian (2003), Dutta and Jackson (2000), Feri (2004a, 2004b), Haller and Sarangi (2001) and Watts (2001). There have also been several experimental tests of the predictions of the connections model; see e.g. Falk and Kosfeld (2003), Callander and Plott (2004) and Goeree et al. (2004).

[3] Examples which can be interpreted in this spirit are telephone calls in which people exchange information, investments in personal relationships which create a social tie yielding value to both partners, and the creation of blogs (short for web log). When a blog user i enters another blog user j, he or she can leave a comment and this automatically creates a link from j to i.

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