



The formation of networks with transfers among players

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Abstract

We examine the formation of networks among a set of players whose payoffs depend on the structure of the network, when players may bargain by promising or demanding transfer payments when forming links. We vary three aspects of the game: (i) whether players can only make transfers to (and receive transfers from) players to whom they are directly linked, or whether they can also subsidize links that they are not directly involved in, (ii) whether or not transfers relating to a given link can be made contingent on the full resulting network or only on the link itself, and (iii) whether or not players can pay other players to refrain from forming links. We characterize the networks that are supported under these variations and show how each of the above aspects either accounts for a specific type of externality, or deals with the combinatorial nature of network payoffs.

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1. Introduction

Many social, economic, and political interactions take the form of a network of bilateral relationships. This ranges from friendships to trading relationships and political alliances. As the

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structure of the network of relationships can have a profound impact on the welfare of all the involved parties, it is essential to develop a good understanding of which networks are likely to form and how this depends on the specifics of the circumstances. This paper contributes to a growing literature that models network formation.¹

Here, our focus is on the role played by *transfers payments* in the formation of social and economic networks. In many applications, agents bargain on possible transfers at the time of forming relationships. For example, when two airlines form a code-sharing agreement, included in that agreement are the details of how the costs and revenues on cross-booked passengers are to be split. Similarly, when two political parties form an electoral pact, they explicitly or implicitly agree on the division of seats, committee positions, cabinet posts, and government benefits. Even in many social relationships, there may be implicit or explicit arrangements in terms of who bears how much of the cost (e.g., in the writing of a paper) and these may be essential to maintaining the relationship. Without transfer payments (in currency or in kind), many agreements would simply never exist.

Our first objective in this paper is to construct a simple model where the agreement on transfers is part of the process of the formation of links. Our second objective is to study how the formation of networks depends on the types of transfers that agents can make. How important is it that agents can subsidize the formation of links that they are not directly involved in? How important is it that agents be able to make payments contingent on the full network that emerges? What is the role of making payments to other players if they refrain from forming links? Since the types of payments that agents will have at their discretion depends on the application, the answers to these questions help us to understand the relationship between the networks that emerge, and for instance whether efficient networks form, and the specifics of the social or economic interaction.

Our results outline some simple and intuitive relationships between the types of transfers available and the networks that emerge. The main results can be summarized as follows. If transfers can only be made between the players directly involved in a link, then the set of networks that emerge as equilibria are characterized by a balance condition. While there are some settings where efficient networks are supported with only direct transfers, there are many settings where the networks that form will be inefficient. If players can make indirect transfers, so that they can subsidize the formation of links between other players, then they can properly account for some forms of positive externalities. However, even with indirect transfers, we still need to worry about the fact that there are many different combinations of links that players might consider forming or not forming. Thus, even though links are bilateral, the multitude of such relationships results in some multilateral decision problems. This means that in order to guarantee that efficient networks form, players need not only to be able to make indirect transfers in order to deal with (positive) externalities, but also to make those transfers contingent on the network that emerges in order to take care of the multitude of interrelated bilateral problems. Thus, there is a basic sense in which one can view the role of indirect payments as taking care of externalities, and contingencies as taking care of the combinatorial nature of network formation. Finally, in order to handle negative externalities, players need to be able to pay other players not to form links. Our analysis also includes some discussion of how to model equilibrium, and we defer all discussion of that analysis until we have laid out the details of the network formation games. This outlining of the relationship between the types of transfers admitted and the types of externalities and

¹ See Jackson [11] for a survey of the literature that is most closely related to our work here.

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